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CRANIAL VENOUS SINUSES

CORRELATION BETWEEN ROENTGENOGRAMS OF THE OCCIPITAL BONE AND THE QUECKENSTEDT (TOBEY-AYER) TEST

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It has been demonstrated previously that roentgenographic evidence of the relative volumes of the lateral sinuses corresponds to comparative anatomic evidence of the bony markings on the occipital bone.[1] The value of a clinical method for the demonstration of comparative volumes of the lateral sinuses has been briefly discussed in the presentation of that evidence. In order to elucidate further the relation between the actual volume of a sinus and a roentgenographic presentation of that volume, it appeared desirable to compare the responses of the internal jugular veins obtained during the performance of the Tobey-Ayer test with the roentgenographic picture of the markings of the lateral sinuses on the occipital bone of the same person. Since the result of the Tobey-Ayer application of the Queckenstedt test is directly influenced by the caliber of the major efferent cranial vessels, the presence of a favorable correlation should further indicate the clinical value of such roentgenograms.

For the purpose of this study, manometric investigations of the dynamics of the normal spinal fluid were performed on 100 patients in the general surgical wards of the Johns Hopkins Hospital. The original technic was used, and the qualifying factors noted by the originators of the Tobey-Ayer test [2] were taken into account. The response of the spinal fluid pressure to compression of the internal jugular vein on

From the Department of Surgery and the Department of Roentgenology, Johns Hopkins Hospital.

1. Woodhall, B.: Variations of the Cranial Venous Sinuses in the Region of the Torcular Herophili, Arch. Surg. **33**:297-314 (Aug.) 1936. Woodhall, B., and Seeds, A. E.: Cranial Venous Sinuses: Correlation Between Skull Markings and Roentgenograms of the Occipital Bone, ibid. **33**:867-875 (Nov.) 1936.

2. Tobey, G. L., Jr., and Ayer, J. B.: Dynamic Studies on the Cerebrospinal Fluid in the Differential Diagnosis of Lateral Sinus Thrombosis, Arch. Otolaryng. **2**:50-57 (July) 1925.

either side, the speed of the response on application of the compression and on its release and the response to simultaneous compression of the

COMPILATION OF RESULTS

Interpretation of Roentgenograms	No.	Findings on Performance of Tobey-Ayer Test	No.
1. Right lateral sinus greater than left			
Slight difference	11	Response of right internal jugular vein greater than that of left	5
Moderate difference	5	Responses equal	6
Pronounced difference	6	Response of right internal jugular vein greater than that of left	5
	22	Response of right internal jugular vein greater than that of left	6
			22
2. Right lateral sinus visible; no left	5	Response of right internal jugular vein present; little if any response of left internal jugular vein	4
		Response of right internal jugular vein greater than that of left	1
			5
3. Left lateral sinus greater than right			
Slight difference	11	Response of left internal jugular vein greater than that of right	6
Moderate difference	3	Responses equal	5
	14	Response of left internal jugular vein greater than that of right	3
			14
4. Left lateral sinus visible; no right	3	Response of left internal jugular vein present; little if any response of right internal jugular vein	2
		Response of left internal jugular vein greater than that of right	1
			3
5. Both lateral sinuses visible and of equal volume	40	Responses equal	28
		Response of right internal jugular vein slightly greater than that of left	10
		Response of left internal jugular vein slightly greater than that of right	2
			40
6. Indistinct markings	16	Responses equal	12
		Response of right internal jugular vein greater than that of left	2
		Response of left internal jugular vein greater than that of right	2
			16

RÉSUMÉ

Roentgenograms	No.	Tobey-Ayer Tests	No.
Right lateral sinus greater than left	22	Response of right internal jugular vein greater than that of left	29
Right lateral sinus visible; no left	5	Response of right internal jugular vein present; no response of left	4
Left lateral sinus greater than right	14	Response of left internal jugular vein greater than that of right	14
Left lateral sinus visible; no right	3	Response of left internal jugular vein present; no response of right	2
Both lateral sinuses sicible and of equal volume	40	Responses equal	51
Indistinct markings	16		100
	100		

internal jugular veins were recorded, frequently by means of a simple tambour and sphygmograph. After the completion of each manometric

study, roentgenograms of the occipital bone in the anteroposterior plane were taken for comparison.

COMMENT

This study of a second series of 100 roentgenograms of the occipital bone of persons on whom precise manometric studies of the dynamics

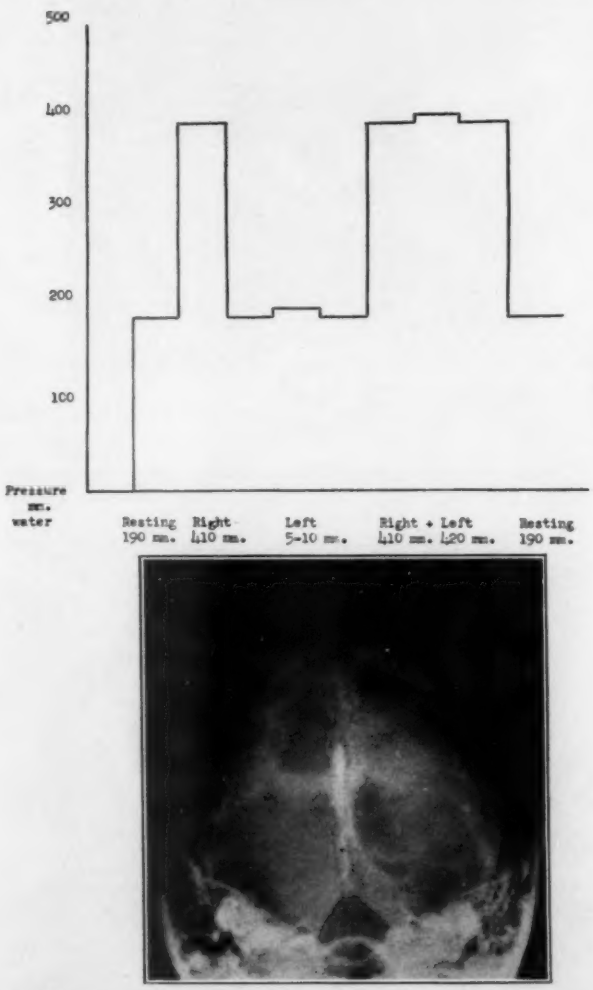

Fig. 1.—*A*, diagram of the response to the Queckenstedt (Tobey-Ayer) test of a patient with a unilateral cranial sinus pattern. *B*, cranial roentgenogram of the same patient. Markings of the right lateral sinus are visible. No markings of the left lateral sinus are visible.

of the normal spinal fluid have been made by the method of Tobey and Ayer indicates again that such roentgenograms may be considered a

reliable index of the volume of the lateral sinuses. In the relatively low percentage of cases in which the markings of the lateral sinuses are not distinct in the occipital projection, roentgenographic study of the base of the skull, with visualization of the size of the jugular foramens, may

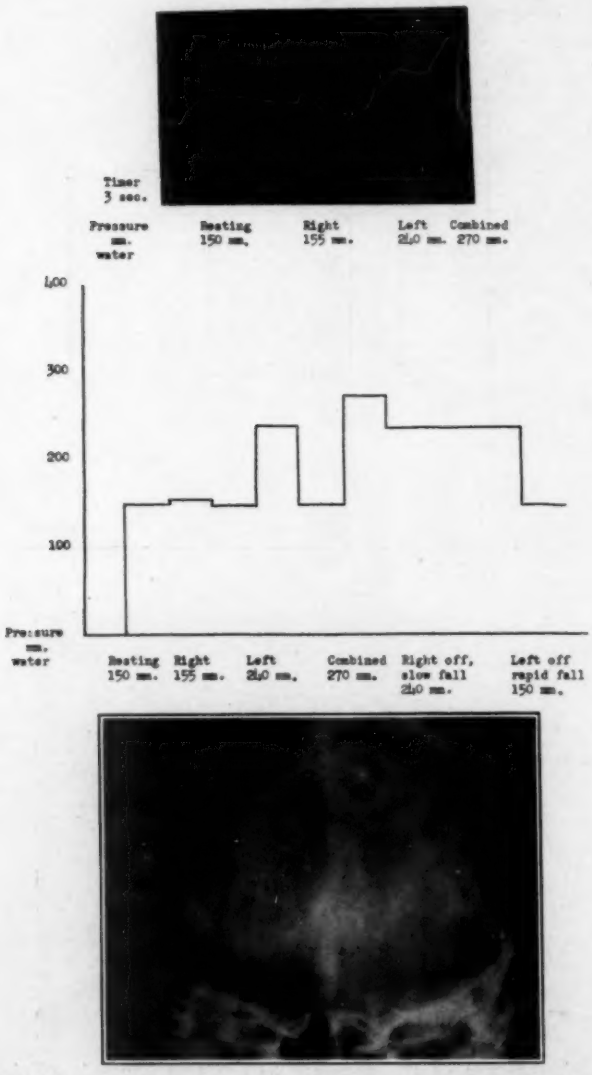

Fig. 2.—*A*, kymographic record of a positive response to the Tobey-Ayer test on compression of the right internal jugular vein. The response was negative, or normal, on compression of the left internal jugular vein. *B*, diagram of response to the Tobey-Ayer test for a patient with a unilateral cranial sinus pattern. *C*, cranial roentgenogram of the same patient. Markings of the left lateral sinus are visible. No markings of the right lateral sinus are visible.

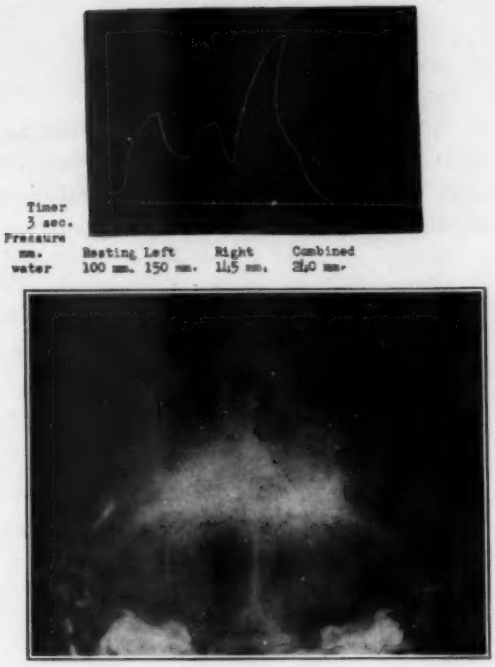

Fig. 3.—*A*, kymographic record of a patient with a bilateral and equal response to the Queckenstedt (Tobey-Ayer) test. *B*, cranial roentgenogram of the same patient, showing markings of bilateral and equal sinuses.

Fig. 4.—Cranial roentgenogram of a patient in whom the right jugular foramen was larger than the left.

be substituted. Although a statistical study has not as yet been completed of the latter projection, it is evident that a combined occipito-basilar visualization of the markings of the lateral sinuses and of the jugular foramens should provide complete roentgenographic evidence of the comparative volumes of these major efferent cranial vessels.

EVOLUTION OF TREATMENT OF FRACTURE OF NECK OF FEMUR

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The purpose of this article is to present an account of the evolution of the treatment of fractures of the neck of the femur, more specifically of those of the transcervical type.

In the exhaustive survey made toward this end I have tried to take up the various methods in chronologic order as much as possible. In a few exceptional cases, as in the discussion of the open treatment of these fractures, I have found it necessary to deviate from the general plan mentioned.

Of all the fractures with which the surgeon has had to deal, it is generally conceded that the one that has given him the most trouble and disappointment is the fracture of the hip. Until recently the best that he could expect to promise was bony union and a cure in about 1 out of 3 cases. While a similar state of affairs formerly obtained for fractures of the patella, the carpal scaphoid and the olecranon, at present the improved methods of treatment of these fractures have surmounted the dangers of failure of bony union. There remains, therefore, only the problem of the fractured hip to contend with; and in the light of present day interest and progress in this field, the handicaps in treatment of this fracture likewise seem doomed, and success appears on the horizon.

Up to the present time, with only such a poor prognosis to offer, namely, bony union in 1 of 3 cases, the surgeon's attitude and approach toward new cases have not been happy. It has been stated that in some of the very large, active hospitals patients with such fractures were refused admittance because they occupied limited bed space futilely and for such prolonged periods. Since so little could be done for them at the hospital, it was thought that they should be cared for at home.

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The illustrations for this article have been taken from other publications. In each instance the name of the author is given in parentheses at the end of the legend, and the complete reference to the source appears under the author's name in the bibliography.

The method of treatment of such fractures has been constantly changing because of all too frequent failures. I shall therefore endeavor to trace the history of their treatment from the time of the earliest recorded case, with its feeble and profoundly inadequate management, through the period during which various types of crude and uncomfortable splints were used, to a period when the condition was generally regarded as hopeless and nothing but conservative methods were applied, such as the placing of a pillow under the knee; then on through a period of more or less inactivity until the plaster of paris abduction treatment became the vogue; and finally, as surgery became more highly perfected, to the period of introduction of the more radical methods of internal fixation used at the present time. The last-mentioned methods seem unquestionably to have opened up a new avenue in this field, and because of the remarkably successful results reported to date they promise to be regarded as the greatest advance made in orthopedic surgery in the last quarter of a century.

During the compilation of the data for this historical survey, I could not but be impressed by the emphasis placed (rightly) by our predecessors on the anatomic, pathologic, mechanical and clinical aspects of the condition as applied to its treatment. A proper consideration of the anatomy of the hip joint, the osseous structure of the neck of the femur, the classification of the types of fracture in this region, the displacements of the fragments and the cause, signs and symptoms of this fracture is therefore essential to a clearer understanding and evaluation of the early efforts made in its treatment.

DEFINITION AND CLASSIFICATION

Formerly fractures of the neck of the femur were classified as either intracapsular or extracapsular fractures, according to their location within or without the capsule of the hip joint. At present they are more accurately designated as subcapital (fig. 1) or near the head, transcervical or central, and basal, or near or through the base of the neck.

The fracture may also be impacted, incomplete, complete, oblique, transverse or comminuted. The fractures that appear impacted on roentgen examination often are those in which severe displacement is present, such as when the fragments occupy an end to side position. The roentgenograms in such cases are deceptive unless lateral views are taken. Rarely a true impacted fracture has been observed, in which case the patient was up and about with no immobilization applied. The incomplete and impacted ones occur more often at the base, while the complete fracture is found in the proximal or central regions. The comminuted type usually is produced by a direct fall on the greater

trochanter. The prognosis is better in such cases, because of the greater amount of force required to fracture the bone, than it usually is for the senile patient.

ETIOLOGY

Fracture of the neck of the femur usually occurs in persons over 50 years of age. There is a slight predominance of women over men.

Owing to the fact that the fracture commonly occurs in the aged, in whom degenerative changes in the neck of the femur are frequently found, such as absorption and rarefaction of bone, the ease with which this fracture follows trauma may well be imagined. Some authorities go so far as to state that often it is a slight sudden twist of the leg, occurring, for instance, as the result of getting the toe of the shoe

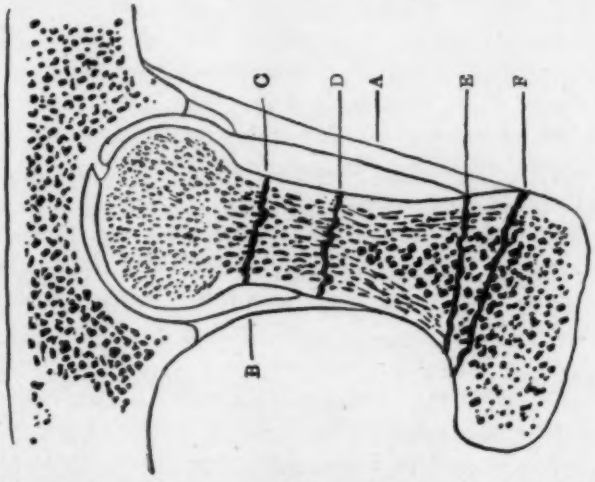

Fig. 1.—Sites of fracture. (From Wilson and Cochrane.)

caught on a rug or against a rough pavement or curbstone, that actually causes the fracture and that the fall that takes place is a result rather than the cause of the injury. A direct fall on the feet from a height or a fall on the trochanter may also produce this fracture. This is more often the case with younger or middle-aged persons, in whom osteoporotic changes in the neck of the femur are not yet present.

CLINICAL SIGNS

The typical picture of a patient with fracture of the neck of the femur is that of an aged person lying in the supine position with the affected leg apparently helpless and rolled outward, so that the outer border of the foot is lying on the pavement or floor. Slight adduction of the limb is noted. On comparative measurement of both legs, the affected one shows shortening. The iliotibial band is found to be

relaxed. There is local tenderness over the greater trochanter. The tip of the greater trochanter lies above Nélaton's line, a line drawn from the anterior superior spine of the ilium to the tuberosity of the ischium. The base of Bryant's triangle is shortened. This is determined with the patient lying on his back. One side of the triangle is a perpendicular from the anterior spine to the table, and the other side is one joining the anterior superior spine of the ilium and the tip of the greater trochanter. The base is a line running horizontally from the tip of the greater trochanter to the perpendicular line. The roentgen findings are essential for the final diagnosis and for determining the type of fracture.

ANATOMY OF THE HIP JOINT

The hip joint is a ball and socket joint composed of the cup-shaped acetabulum and the almost spherical head of the femur. The strong capsular ligaments and the teres ligament enclose the joint and maintain it in place. The capsular ligaments are attached to the rim of the acetabulum and to the anterior and posterior intertrochanteric lines of the femur, incorporating the major portion of the neck of the femur within the capsular joint space.

The acetabulum is a large cup-shaped cavity on the lateral aspect of the hip bone. The lower part is deficient, and the gap is called the acetabular notch; a fibrous band called the transverse ligament fills in this gap.

The upper end of the femur is made up of the head, the neck and the greater and lesser trochanters. The head, which is rounded and forms more than a hemisphere, is directed upward, inward and a little forward. There is an ovoid depression, the fovea, on its smooth surface just below and behind the center, to which the ligamentum teres is attached.

The neck is the thick bar that connects the head with the body in the region of the trochanters. It is nearly 2 inches (5 cm.) long, is thinnest in the middle and is widest toward each end, especially the end which joins the body. The neck joins the body at an obtuse angle of 125 to 135 degrees. The obliquity of the neck varies with the age of the person and ranges from a gentle curve in infancy to almost a right angle in old age.

The greater trochanter is the large square prominence on the lateral aspect of the femur, where the neck joins the shaft. Its root is marked off from the shaft by a more or less horizontal ridge on its lateral aspect, called the vasternus line. The powerful outward rotator muscles of the thigh are attached to the greater trochanter.

The lesser trochanter is the rounded conical projection on the posterior and medial aspect of the bone, where the lower part of the neck joins the body.

The anterior intertrochanteric line is the rough broad line which extends from the upper part of the anterior surface of the greater trochanter toward the lesser trochanter. The posterior intertrochanteric line connects the upper and back part of the lesser trochanter on the posterior surface of the neck of the femur.

The head is covered with cartilage and so is the acetabulum, with the exception of the depressions found in both for the attachment of the teres ligament. A mass of fat covered with synovial membrane occupies the acetabular notch.

The capsular ligament (figs. 3 and 4) of the hip joint, a strong, dense ligamentous capsule, is made up of three portions: the iliofemoral, pubofemoral and ischiocapsular ligaments. It is attached at the brim of the acetabulum above; below, it is attached in front to the femur along the anterior intertrochanteric line, above to the neck a little short of its junction to the greater trochanter, behind to the neck itself about ½ inch (1.3 cm.) from the posterior intertrochanteric line, and below to the upper part of the lesser trochanter.

Thus there is formed a sort of tubular sheath embracing the hip joint. It consists of two sets of fibers, circular and longitudinal. The circular fibers, the zona orbicularis, are most abundant at the lower and back part of the capsule and form a sling or collar around the neck of the femur. The longitudinal fibers are most numerous at the upper and front part of the capsule, where they form distinct bands or accessory ligaments, of which the most important is the iliofemoral ligament. Other accessory bands are the pubofemoral and ischiocapsular ligaments.

The ligamentum teres is a triangular band the apex of which is inserted into the depression in the head of the femur, and its broad base takes origin in the margins of the acetabular notch, becoming blended with the transverse ligament that bridges this notch. It runs upward from the acetabular notch to the head of the femur. It consists of connective tissue, surrounded by a tubular sheath of synovial membrane. Sometimes only the synovial fold exists. The ligamentum teres on rare occasions may be absent.

Circulation.—The circulation (fig. 5) to the hip joint is derived from the circumflex artery of the profunda femoris, the external circumflex and the superficial circumflex iliac of the femoral artery. According to Kolodny, there are four sets of blood vessels to the head and neck of the femur: 1. Vessels from the shaft, which enter from the superior nutrient artery and through the neck to the head; (2) periosteal vessels, which pass superficially along the borders of the neck into the head (as the existence of periosteum on the neck of the femur is disputed, these vessels should probably be called, according to W. C. Campbell, synovial, as they must pass in the synovial membrane which is reflected

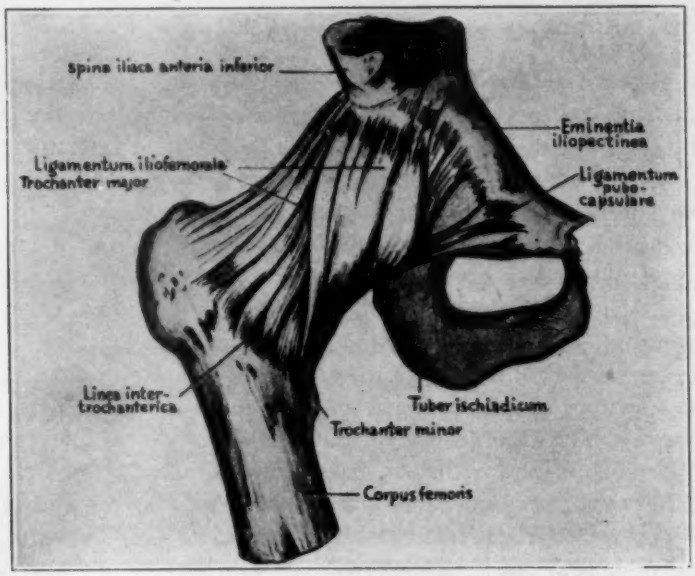

Fig. 3.[1]—Drawing of the hip, anterior view, showing the ligaments. The ligamentum iliofemorale, or Y ligament, is prominent. (From Campbell.)

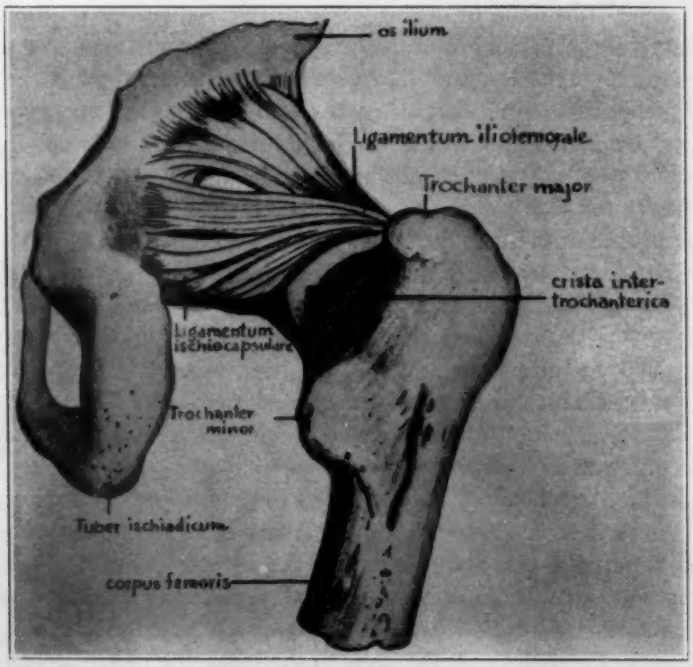

Fig. 4.—Drawing of the hip, posterior view, showing the ligaments, including the ischiocapsular and ischiofemoral ligaments. A considerable portion of the posterior aspect of the extracapsular portion of the femoral neck is also shown. (From Campbell.)

1. Figure 2 has been omitted.

over the neck); (3) epiphysial vessels, which pass to the epiphysis from the capsule, and (4) vessels from the ligamentum teres, which enter the head at the depressed area known as the fovea.

W. E. Wolcott preferred to designate the circulation of the hip joint as consisting of a threefold blood supply: (1) ligamentum teres artery, (2) posterior superior visceral capsular arteries and (3) posterior inferior visceral capsular arteries.

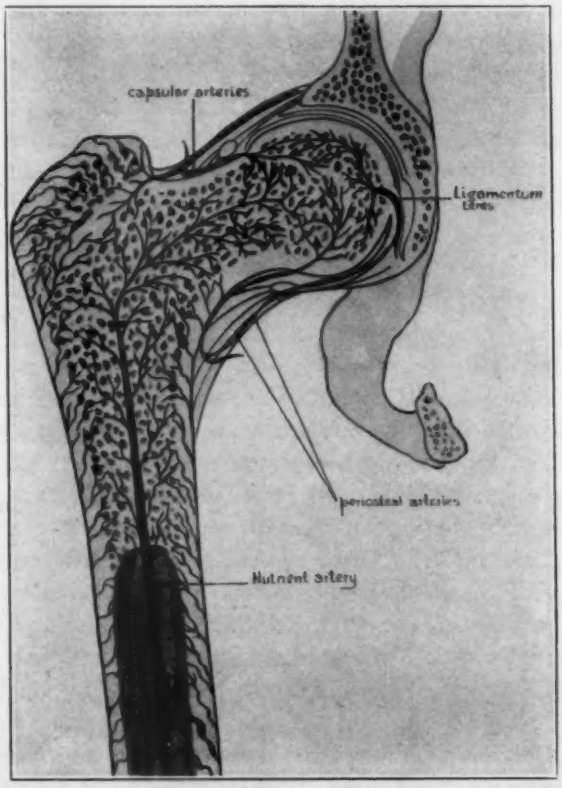

Fig. 5.—Schematic drawing showing circulation to the head and the neck of the femur. (From Campbell.)

Muscle Action.—The muscles which flex the femur on the pelvis are the iliopsoas, the rectus femoris, the sartorius, the pectineus, the adductor longus, the adductor brevis, the anterior fibers of the gluteus medius and the gluteus minimus.

Extension at the hip joint is mainly performed by the gluteus maximus assisted by the hamstrings.

The thigh is adducted by the adductor magnus, the adductor longus, the adductor brevis, the pectineus, the gracilis and the lower and upper parts of the gluteus maximus.

The muscles which rotate the thigh inward are the anterior fibers of the gluteus medius, the gluteus minimus and the tensor fasciae femoris; those which rotate it outward are the posterior fibers of the gluteus medius, the fibers of the piriformis, the obturator externus, the gemelli, the quadratus femoris, the iliopsoas, the gluteus maximus, the three adductors, the pectineus and the sartorius.

DISPLACEMENTS

The proximal or head fragment in intracapsular fracture of the neck of the femur possesses extreme mobility because of its smooth and lubricated surface, because of the presence of blood and synovial fluid, because of its position within a tube of capsule (even though this is torn, as frequently is the case) and because with the single exception of the ligamentum teres there is no other structure attached to it that might prevent its motion. The various positions that this fragment can assume in respect to that of the neck fragment are therefore many.

The head fragment, then, can assume various positions in respect to the neck fragment. It may be tilted backward or in external rotation; forward, or in internal rotation; upward, or in flexion; downward, or in hyperextension; or it may remain in the neutral position, or normal extension. The commonest positions assumed by the head fragment, however, are forward tilt, upward and neutral. Displacements of the distal or neck fragment are largely due to muscular action and gravity. This fragment usually is pulled upward by the gluteal muscles, the iliopsoas muscle, the adductors and the hamstrings, causing shortening of the limb. It is also outwardly rotated by the powerful gluteal muscles, the piriformis and the gemelli. The force of gravity, because of the angle of the foot to the leg, also enters into the external rotation produced. Likewise, because of gravity, the distal or neck fragment is displaced backward, in relation to the patient's body.

Owing to all these influences, namely, the extreme mobility of the head fragment and the muscular and gravitational effects produced on the distal or neck fragment, the fractured surfaces of these fragments may assume various positions and relations to each other. These are as follows:

1. The open V position. In this position the head fragment is tilted forward and the neck fragment rotated outward, so that the posterior edge of the head fragment fracture surface is cocked on the fracture surface of the distal fragment.

2. The neutral position. The fracture surfaces are approximated to each other, probably with a little upward and backward displacement of the distal fragment. This often is the case in impacted fractures.

3. Placement of the fracture surface of the capital fragment behind the neck of the cervical fragment.

4. Placement of the fracture surface of the cervical fragment behind the capital fragment.

HISTORY OF TREATMENT

Historically, the great battlefield in fracture surgery has been the fractured hip. The results obtained in the treatment of fracture of the neck of the femur have been far from satisfactory. Numerous methods of treatment have been tried and discarded after their failure has been demonstrated. After the fracture had been reduced, how was it to be kept successfully immobilized, so that nature could be given a chance to heal it? On account of this difficulty one prominent surgeon of the present time has gone so far as to call it the "unsolved fracture."

In this historical survey I shall be concerned mainly with the methods that have been attempted for reduction and for securing immobilization of the fracture.

AMBROISE PARÉ: THE FIRST RECORDED CASE

It is not known for certain whether the ancients had knowledge of the existence of fractures of the neck of the femur. Boyer has stated that, "Although Hippocrates has not, in the exact words, spoken of this fracture there can be no doubt, from several passages in his article on fractures of the thigh-bone, that he had seen it." Malgaigne likewise credited the ancients with positive knowledge of this condition. The first report, however, that has been recorded in the literature is that of Ambroise Paré (1510-1590) in his "Works of Ambroise Paré." This epoch-making report is as follows:

> A fracture sometimes happens at the joint of the hip in the neck of the thigh bone, as I once observed in an honest matron. I being called to her, when I had observed the hurt thigh to be shorter than the whole, with the outward prominence of the ischium, which at the first sight I supposed to proceed from the head of the thigh bone, I presently persuaded myself it was a dislocation. I then therefore extended the bone, and forced (as I thought) the head thereof into its cavitie. The equalities of both the legs in bigness which followed upon this extension, increased my persuasion that it was a dislocation. The next day I visited her the second time, and found her in great pain, her hurt leg shorter, and her foot rested inwards. Then I loosed all her ligatures and perceived such a prominence as I did formerly. Wherefore I endeavored again to force in the head of the bone, as I formerly did. But as I was busied therein, I heard a little crackling and also I considered that there was no cavity or depression in the joint, by which signs I certainly persuaded myself that the bone was broken and not dislocated. Neither only such kind of fractures, but also the separation of the appendix or head of this bone from its place, may induce one to think it a dislocation; which thing has sometimes deceived some heedless surgeons, who have not dreamt of the divulsion or separation of the appendix from the top of the thigh-bone but have judged it only a dislocation.

Then, therefore, I set the bone, and joined the fragments together, laid thereupon splints (fig. 6) with compresses, made ligations with a rowler, having two heads wrapped about the joint, and the body crosswise, and I defended her foote with a case, that none of the clothes might press it. I fastened a rope to a post, and so let it come down into the midst of the bed and tied therein many knots, for the better taking hold and lifting up herself.

Thus, Ambroise Paré became the first to recognize and report a case of fracture of the neck of the femur. Morgagni (1682-1731) was the next. Heister (1683-1758) and Ruysch (1638-1731) described the pathologic appearance of this fracture as observed at autopsy and were definite in their assertions that Paré deserved the credit for first recog-

Fig. 6.—Ambroise Paré's method. A compress and splints are applied to the affected hip with a spica inguinalis bandage over all, a rope suspended from the ceiling and a cradle provided for protection of the feet. (From Hindinarst.)

nizing it. Later, Petit, Henry Earle, John Bell and others likewise looked on Paré as the pioneer in this field.

The treatment employed by Ambroise Paré consisted simply of compresses applied about the hip joint with splints and a spica inguinalis bandage over all.

This method, then, the crudity and inefficiency of which are so apparent, constitutes the first method of treating a fracture of the neck of the femur of which record is found in the literature.

The next method was that of Fabricius Hildanus (1537-1619). It was called the girt or belt of Hildanus (fig. 7) and consisted of a "belt drawn and buckled very tightly above the knee, the belt being first introduced through the eyes of two hooks," one on the outer and the other on the inner aspect of the knee. The ends of a rope were attached to these hooks. A double pulley was attached to the middle of this rope, and another pulley was tied to the eye of a screw made fast to the foot of the bed. A series of ropes was passed through, connecting both pulleys with the free end used to modify the amount of extension applied to the leg.

Counterextension was obtained by the use of two sheets which acted as perineal bands and were attached to each side of the headposts of the bed.

Fig. 7.—Girt of Hildanus. Traction is produced by means of a system of pulleys attached on one side to a rope which is anchored at the knee by two hooks and a circular strap above the knee and on the other side to a screw fastened to a wall of the room. (From Boyer.)

In the method of Hildanus one sees the principle, of extension and counterextension applied for the first time in the treatment of fracture of the neck of the femur.

Lawrence Heister (1683-1758) made use of this method, as described by him in his "System of Surgery," published in 1750.

Benjamin Gooch (?-1780) sought a better method than that of Hildanus by applying the principle of distention (fig. 8). He used a metal ring at the upper part of the thigh and one for the lower part, just above the knee. Two metal rods were fixed to the outer and inner parts of the upper ring and were shaped in the form of a screw at their lower ends. The lower ring had attached to it on each side an eye through which the screws of the side pieces worked. Then with a special screw key the side pieces could be lengthened as desired to get the effect of distention. For immobilization, a splint of thin timber was wrapped around the thigh and held in place by fillets.

Gooch attempted by this method to apply an old principle, known and employed by Hippocrates, namely, the principle of distention or distraction, such as was used for fracture of the shaft of the femur.

John Aitken (?-1790), of Edinburgh, improved on Gooch's machine by using a firm leather strap lined with soft flannel, applied around the pelvis (fig. 9). Three metal splints were attached to this strap and to a lower leather strap just above the knee by passing through three iron screw plates. They were fixed by screw nails passing through one of the holes at the lower end of the steel splints. Thus the length of the steel splint could be graduated as desired for distraction. A soft strap which was forked at its lower free end was fixed to the back part of the upper circular strap. The forked ends were brought around each side of the thigh and tied around the forepart of the circular strap to secure it from moving upward.

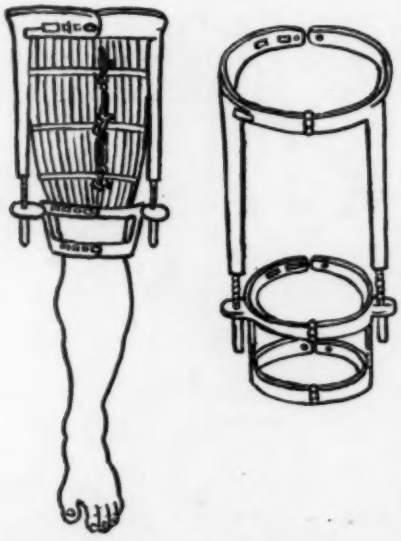

Fig. 8.—Gooch's machine, utilizing the principle of traction and countertraction by a process of "distention" or "distraction" regulated by the two screws at the lower ends of the side pieces. (From Boyer.)

Jean Louis Petit (1674-1750) described a case of fracture of the neck of the femur that he treated by means of extension and counter-extension. He obtained the latter by a sheet or perineal band across the groin of the sound hip and the former by two extension straps, one above the condyles of the knee and one above the malleoli. Each of the latter two straps was made fast to the foot of the bed, and they were used alternately for the convenience of the patient. A long outer junk or pasteboard splint from the crest of the ilium to beyond the foot and a shorter inner junk from the groin to beyond the foot were fastened to the leg by means of crosswise straps. A napkin drawn around the pelvis to fix the upper end of the long outer splint was applied. A sole fastened by a double strap served to keep the foot firm. A cord was

fastened to the ceiling, dropping to the middle of the bed within reach of the patient's hands to provide support.

The principle of extension and counterextension was employed as the sole method of treatment up to this point. The next method to be mentioned was exactly opposite, namely, treatment with the limb in semi-

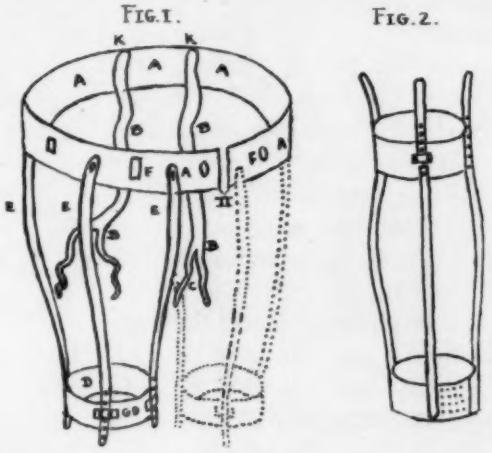

Fig. 9.—Aitkin's machine, operating on the same principle as the Gooch machine except that a waistband is substituted for the band in the groin. (From Boyer.)

Fig. 10.—Percival Pott's method, utilizing the semiflexion position to relax the muscles and thus balance the forces on the osseous fragments at the site of fracture. (From Boyer.)

flexion. The great advocate, as well as the original proposer, of this position was Percival Pott (1713-1788), who was said to have worked a complete revolution in this department of surgery. Pott placed the patient on the affected side (fig. 10), with the plane through the anterior superior spines of the ilii perpendicular to the horizon, the thigh

drawn up to an obtuse angle with the pelvis and the leg bent to a right angle with the thigh. This position was believed by its originator to accomplish the effect of immobilization of the fragments and at the same time to prevent a displacement of the fragments at the fracture site by having the extensor and flexor muscles of the thigh in complete neutralization and balance.

While Pott's method itself did not become widespread in its use, it will be noted how his principles, semiflexion and muscular balance, were utilized again and again in other methods to be described later.

Desault (1744-1795) raised objections to this position on the grounds that (1) there was the difficulty of making extension necessary on the broken bone, (2) the impossibility of accurately comparing the two limbs, (3) the inconvenience of lying on the side, (4) the injurious pressure sustained on the greater trochanter, (5) the danger of derangements to which the fracture was liable when the patient went to stool and (6) the difficulty of firmly fixing the leg.

Desault therefore improvised a splint (fig. 11) which he believed obviated these difficulties. It returned to the principle of extension and counterextension. The description of the Desault splint is as follows:

A long flat wooden splint from the crest of the ilium to about 6 inches (15 cm.) beyond the foot was used as an outer splint. The lower end of the splint was notched and had a mortise to which the lower extending bandage around the leg was tied. A bandage was placed around the pelvis to secure this splint from being displaced upward; also, to aid in this respect, there was a bandage passing around the upper end of this splint and across the perineum, the tuberosity of the ischium acting as the anchoring support. An anterior splint from the groin to the knee was applied and held in place by four circular straps around the thigh, incorporating the external splint. Three circular straps maintained the latter splint to the leg. A figure of eight bandage around the foot was tied to the mortise in the notch at the lower end of the splint. Desault believed that this splint satisfied the three essential requirements for osseous union, namely, to keep the body of the femur down, to retain the pelvis up, and to secure the foot in a straight line with the leg as much as possible. Before the time of Desault, counterextension was made by a perineal band fastened to the headboard of the bed whereas Desault applied counterextension by means of his long "permanent extension" splint.

[NOTE.—Desault's wife suffered a fracture of the neck of the femur in 1830 and died of pneumonia after one month. Paradoxically, she was treated by use of the double inclined plane, the prevalent method of the day.]

PERIOD OF SIR ASTLEY COOPER

The next period was that of Sir Astley Cooper (1768-1841), who made the treatment of intracapsular fracture of the neck of the femur a subject of lively debate among his contemporaries. This period is considered by many authorities as that in which the first serious contributions on the nature and treatment of this condition were made. In fact, many of the recent articles dealing with the method of treatment of such fracture declare that the first rational treatment dates back to Sir Astley Cooper. He was the exponent of conservative treatment. This is very well described in his own words, which have been quoted frequently in the literature on this subject:

> Not having found any mode of treatment succeed in effecting ossific union in these cases, and having repeatedly seen the patient's health much injured by the trials which have been made, all that I now direct to be done, is, that a pillow should be placed under the limb for its whole length, and a second rolled up, put under the knee, and that the limb should be allowed to remain upon these

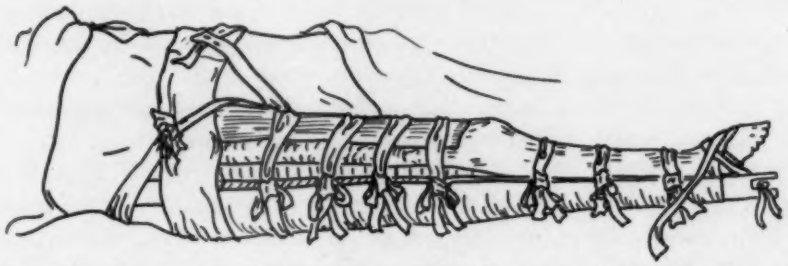

Fig. 11.—The Desault splint. A long side splint and a short anterior splint are used, and permanent traction is maintained by fixing the foot to a notch at the distal end of the long splint and anchoring the hip to the proximal end of this same splint. (From Boyer.)

> for 10 days or a fortnight, until pain and inflammation have subsided; the patient should then be allowed to rise and sit in a high chair; to prevent much flexion of the limb, which would be painful, in a few days more he should begin to walk with crutches, and after a time, a stick should be substituted for the crutches, and in a few months he will be able to use the limb without any adventitious support; when he commences to bear the weight of the body on the limb he should be provided with a high heeled shoe which will much assist him.

Notable among Sir Astley Cooper's contributions to knowledge of this subject was his clear segregation of the fractures into two classes: (1) fractures through the neck proper ("intracapsular"), and (2) fractures through the trochanters ("extracapsular"). He was the first to bring out the importance of this fact and its bearing on the ultimate prognosis. In his time the outlook for fractures of the first type was extremely poor, while that for fractures of the second type was very good.

While Sir Astley Cooper claimed that bony union was difficult to obtain for "intracapsular" or transcervical fractures because of want of proper apposition, adequate lateral pressure on the fragments and deficient nutrition of the parts due to severance of the articular capsule, he did not deny the possibility of osseous union; "if a fracture should happen without the reflected ligament being torn, nutrition would continue and the bones might unite."

Therefore, Cooper was primarily interested in saving life rather than in obtaining osseous union at the site of fracture. But this conservative attitude did not go unchallenged; in fact, the feeling in the opposing camp, composed of Dupuytren, Boyer, Malgaigne, Charles Bell, Henry Earle and others, was strongly in favor of the belief that osseous union was possible and therefore that efforts should be made toward positive and deliberate treatment to attain this end.

Philip Physick (1768-1867) modified Desault's method by increasing the length of the outer splint to reach the axilla of the affected side. The splint ended in a crutchlike form for comfort in the axilla. The counterextension band was made to go from the perineum to a mortise-hole in the splint, high up near the axilla.

To keep the foot from being pulled outward and pressed against the external splint, Hutchinson modified Physick's splint by attaching a wooden block to the inner aspect of the lower end of the external splint. The extending band around the foot and ankle was then made to go across the inner, or free, end of this block of wood, thus keeping the foot from pressing against the external splint.

Dupuytren (1777-1835) objected to Desault's splint because the external splint caused pressure necrosis of the soft tissues over the greater trochanter and pain at the hip. These objections, he stated, often necessitated removal of the apparatus, and shortening of the leg would follow. This occurred in the case of General Lafayette. (Mention is made of this case only because of its historical interest.)

His mode of treatment consisted first in reducing the fracture by flexing the thigh on the abdomen and the leg on the thigh and then "drawing the thigh from the abdomen." This caused the limb to overcome the shortening and assume its natural length and the foot to correct its eversion into the neutral position. Then he kept the limb in flexion at the hip and knee by means of the double-inclined plane, which had been previously popularized and extensively used by Sir Astley Cooper up to the time that he discarded all methods of treatment except the pillow under the knee method. Sir Astley Cooper gave credit to White, of Manchester, England, as first suggesting the double-inclined plane method and added that it was later improved on by James, of Hoddesdon. The latter placed hinges at the angle of union of the inclined boards so that the height of the triangular plane could

be modified as desired. The double-inclined plane was a contrivance consisting of three boards placed in the form of a triangle, so that the base of this triangle would rest on the mattress and the thigh of the injured limb on the one side of the triangle, the knee over the apex and the leg over the other side. The principle of this method was that of Pott's semiflexion position of the limb, namely, to obtain muscular relaxation and the position of greatest comfort. A hinge connected the lower angle nearest the hip and another at the apex. The side over which the foot rested and the base formed a ratchet mechanism so that the altitude of the triangle could be varied according to the height desired. Pillows were placed over the apex and two sides of the triangle on which the limb was made to rest with comfort. The lower part of the leg was fixed by passing a cloth folded diagonally across its anterior part and making the ends fast to the sides of the bed, and a similar arrangement was adopted with the thigh.

The point of emphasis in Dupuytren's procedure was not so much in the method of fixation used as in the manner of reduction of the fracture. He flexed the thigh on the abdomen and the leg on the thigh and then gently "drew the thigh from abdomen." This was in contradistinction to the old accepted method of reduction by forceful application of extension and counterextension of the affected leg.

Belloq (1732-1807) devised a complicated machine (fig. 12) which secured extension by means of a jack. It consisted of two lateral splints connected below by a cross piece, on which worked a jack.

Boyer (1757-1833) obtained the same end (fig. 13) by adjusting a foot piece at right angles to his mechanical splint. He used a screw as a windlass to obtain permanent extension. His apparatus was similar to Desault's splint except that it was too complicated and expensive and was not practical for general use.

Brüninghausen, according to Boyer, was the first to place the limb in internal rotation in order to prevent external rotation. He fixed a stirrup to the foot of the bed, to which he tied both feet, using the sound leg to aid in extension. Then he bandaged a leather splint to the outer side of each leg, and the upper end of the bandage encircled the pelvis. He later gave up this form of treatment.

Henry Earle in his book published in 1823 described and illustrated his fracture bed. It was a complicated bed (fig. 14) mechanically adjustable to form a double-inclined plane. There were an opening in the bed for elimination of feces and urine and foot pieces to which the feet were fastened.

Velpeau utilized a method whereby a long roller bandage soaked in dextrin was applied around three wide pasteboard splints (anterior, lateral and posterior) from the toes of the injured limb up to the hip and around the pelvis in spica fashion. This is described in his book

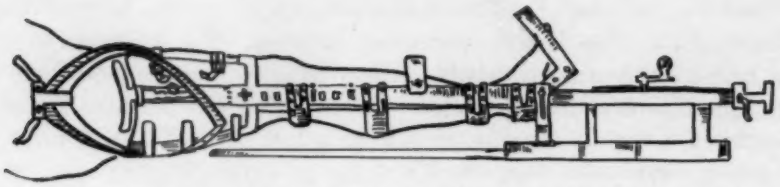

Fig. 12.—Belloq's machine. This device is also similar in principle to Desault's splint, but it is more complicated. A windlass device at the foot serves to exert traction. (From Belloq.)

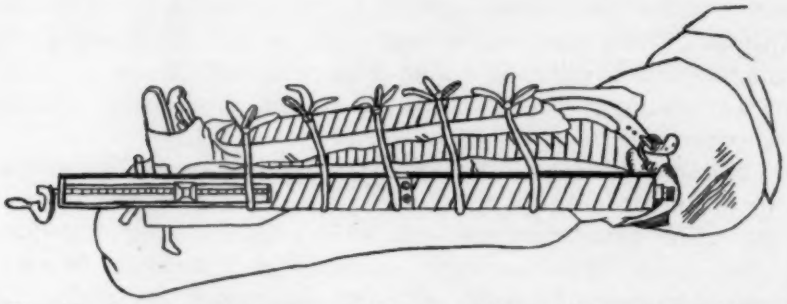

Fig. 13.—Boyer's splint. The principle is similar to that of Desault's splint except that a screw or jack device is used at the foot of the splint for traction purposes. (From Boyer.)

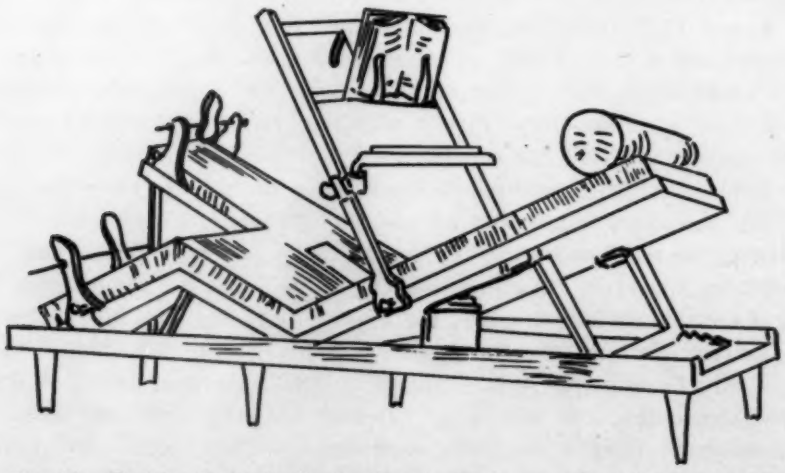

Fig. 14.—Earle's double-inclined plane bed. A complicated bed devised to supply comfort for the patient and immobilization of the fracture at the same time. The principle of the double-inclined plane which Sir Astley Cooper had popularized and the position of semiflexion advocated by Sir Percival Pott were employed here. The foot pieces to which the feet were strapped; the openings for elimination of excretions and for back rubs and the shelf for the dinner tray all were made to serve for convenience and efficiency. (From Earle.)

"Leçons orales" (1841). For extension he used the middle of a piece of strong bandage in the form of a figure of eight about the ankle and tied the ends to the foot post of the bed. A perineal band was applied to the groin and fastened to the head post for counterextension. When the bandages were thoroughly dried these two bandages for extension and counterextension were removed. Therefore, Velpeau was the first to use the hip spica bandage with a material, dextrin, simulating Whitman's plaster of paris spica bandage as the immobilizing agent.

Hamilton in 1860 described Gibson's modification of the Hagedorn splint. This splint consisted of a wooden footboard (fig. 15) to which both feet were fastened at right angles, and the lower ends of two crutches, which ends could be adjusted to the length of the limbs by means of pegs passed through one of the holes in each of the crutches. The crutches were well padded for comfort in the axillas. Thus this splint utilized the well leg for extension of the injured leg and the crutches for counterextension.

Fig. 15. Gibson's modification of the Hagedorn splint. Both feet are strapped to the footpiece so that the extended well leg acts as the agent of counterextension. The crutches are adjusted to their proper length and fixed to the footpiece. Hagedorn's original splint did not make use of the long crutches; the side splints reached up to about the level of the iliac crests and were bandaged to the legs and waist. (From Hamilton.)

Gurdon Buck, in 1861 introduced an improved extension apparatus (fig. 16) for fracture of the thigh. This method, known as Buck's extension, consisted of two long strips of adhesive tape about 2 inches (5 cm.) wide, applied to each side of the leg from the midthigh to about 6 inches (15 cm.) beyond the sole of the foot. The ends of the strips were attached to a wooden block or spreader to relieve the pressure of the adhesive strips against the malleoli. The long strips were secured in place by crisscross and circular adhesive strips around the leg. A cord was attached to the center of the spreader and was made to pass over a pulley fastened to the end of the bed. A weight of 15 to 25 pounds (7 to 11 Kg.) was attached to the end of the cord for weight traction.

While all efforts up to this time were directed toward fixing the fracture by some form of splint or apparatus externally applied, no

attempts had been made toward open operation or internal fixation until von Langenbeck in 1858 first performed an open nail fixation operation on a fractured hip. The operation involved exposing the fracture site and nailing the fragments by means of a nail passing through the greater trochanter, the neck and the head of the femur. Aseptic surgery at this time was not yet heard of.

Koenig in 1875 and Trendelenburg in 1878 did the same type of operation as von Langenbeck's, but Lister in 1880 performed it with aseptic precautions.

Kocher in 1896 advised resection of the head of the femur for fresh fractures, because nonunion, in his opinion, was almost a foregone conclusion.

Returning to the splint methods of treatment of fractured hips, Nathan R. Smith in 1867 demonstrated the use of his anterior suspensory splint (fig. 17). He stated:

> The anterior suspensory splint is applicable, with slight modifications, to all fractures of the femur. To none is it more appropriate, and in none has it accomplished more satisfactory results than in fractures of the cervix femoris, the events of which are so justly regarded as an opprobrium of surgery.

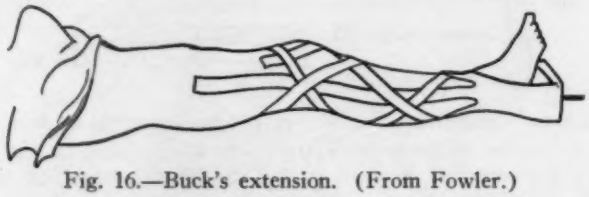

Fig. 16.—Buck's extension. (From Fowler.)

He claimed that his splint provided more comfort than the softest pillow and allowed the trunk more liberty in regard to position. For these reasons he advocated the use of this splint even though osseous union was not expected.

The splint was made up of a single rigid wire frame extending lengthwise from about the level of the iliac crest to the toes. The width corresponded approximately to that of the leg. The side pieces of this frame were strengthened by curved wire cross pieces at distances of about 5 inches (12.5 cm.). They had loops in their centers for attachment of hooks. The wire frame was bent into angles for the ankle and into slight flexion for the knee and for the hip. A muslin bandage was tightly wrapped around the wire frame and applied over the anterior aspect of the leg by means of bandages. To the hook above the knee and to the one at about the middle of the leg were attached the ends of a rope, about 5 feet (152 cm.) in length. The middle of this cord was made to pass through a loop at the end of a cord which was suspended from a system of pulleys fastened to the ceiling at a point perpendicular to a point at the middle of the leg. By slipping

the tenblock up or down the limb was elevated or depressed as desired. The foot of the bed was elevated by 2 inch (5 cm.) blocks. The weight of the body acted as counterextension. Extension was said to be accomplished by the obliquity of the cord, the variation of which would easily graduate the amount of extension desired. Smith claimed that extension was perfectly uniform and that the apparatus did not require the tightening or relaxation of bands from day to day.

Hugh Owen Thomas devised the Thomas ring splint in 1888. It consisted of an ovoid cast steel ring and a V-shaped cast steel rod, the two ends of which were fixed and attached to the ovoid ring. There was a slightly curved notch at the closed end of the V. The traction rope was tied here in cases of emergency traction treatment, for trans-

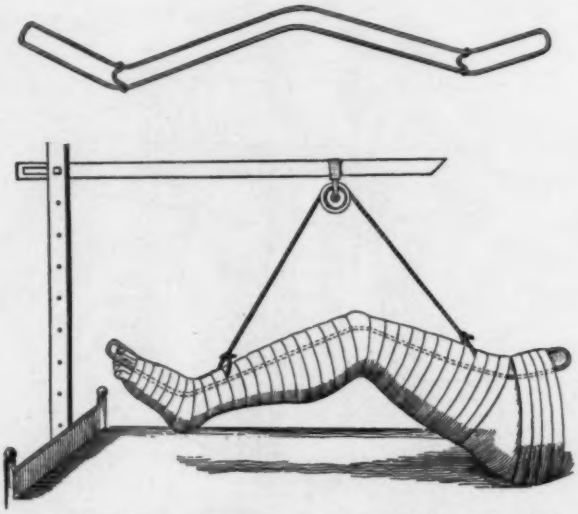

Fig. 17.—Anterior suspensory splint of Smith. (From Senn.)

portation. One arm of the V was shorter than the other, to allow for the obliquity of the groin from its external aspect inward. When in use the ovoid ring was padded with cotton or sheet wadding. The ring was passed around the leg in such a way that it was made to circumscribe the thigh at the groin, pressing against the tuber ischii. The leg was placed on towels which spanned the metal bars and were fastened to these by metal clips. Traction was applied by means of Buck's extension, previously described. This method later came to be used mostly in cases in which Whitman's plaster of paris spica was contraindicated.

Thomas himself preferred to use the Thomas-Ridlon splint (fig. 18), because it immobilized the hip joint above and below so that the hip corresponded to the center of the appliance (lengthwise).

Senn, around 1889, used a plaster of paris spica bandage (fig. 19) with a screw device over the lateral aspect of the greater trochanter, exerting graduated lateral pressure to force the two fragments together.

At about the same time, 1889, Ridlon popularized the Thomas-Ridlon single hip splint. This was devised to maintain fixation of the fragments and to allow the patient to be ambulatory by means of crutches. The splint consisted of a main stem, a chest band, a thigh band and a calf band. The main stem was placed along the posterior aspect of the limb and buttock of the affected side and up the back to

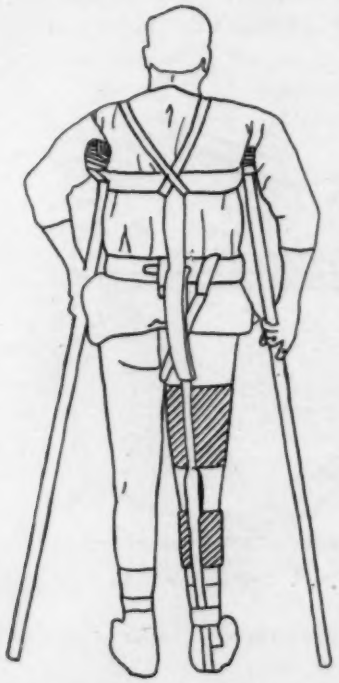

Fig. 18.—Thomas-Ridlon splint for immobilization of the hip joint. (From Keen.)

the level of the axilla. It was curved over the buttock to conform to the contour of the part.

To the lower end, just above the ankle, was fastened (by one rivet) the calf band. The thigh band was also riveted to the stem at about the level of the great trochanter. The chest band was fastened at the upper end of the stem at a level just below the axillas. All these bands were open anteriorly. A hole was forged in each end of the chest band so that the shoulder straps might be attached to it and crisscrossed over the shoulders, to be fastened to the attachment of the chest band to the stem.

The splint was bent to fit the patient approximately, and was padded on the side next to the skin.

Scudder advised the use of Senn's lateral pressure pad over the great trochanter along with the Thomas-Ridlon splint. The limb was bandaged to the splint if retentive traction was not necessary. If the latter was called for, the shoulder straps were omitted.

In 1891, C. R. Ruth first used the "anatomic method," the combined longitudinal and lateral traction method that was introduced by Maxwell in 1871. The method became popularly known as the Maxwell-Ruth method (fig. 20). Maxwell claimed no originality for this mode of treatment but gave due credit for the discovery to G. W. Phillips (fig. 21) who introduced it in 1869. The lateral traction was arranged in such a way as also to maintain internal rotation of the hip,

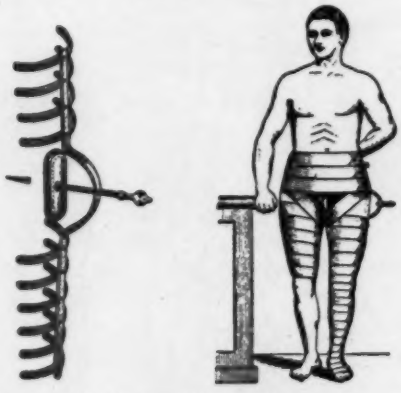

Fig. 19.—Senn's plaster of paris spica bandage, with a screw device over the lateral aspect of the great trochanter. (From Senn.)

i. e., by means of a wide strip of adhesive plaster, application of which was started at the outer aspect of the upper third of the thigh, proceeding internally over the anterior surface of the thigh and then over the posterior aspect to beyond the outer aspect of the thigh. A rope was attached to this end of the adhesive tape and was made to go over a pulley fixed at the side of the bed. Longitudinal traction was obtained in the usual manner, i. e., by Buck's extension.

It is stated in Wilson and Cochrane's book that "the resultant of the two forces acting at right angles to each other is represented by a line passing between the two and corresponds more or less closely to the normal axis of the neck of the femur." Reduction by the Maxwell-Ruth method consisted of flexing the thigh at a right angle to the trunk. Then an assistant exerted an outward pull in the axis of the upper end of the lower fragments. Traction on the limb was made in the long axis of the body.

WHITMAN'S METHOD

With the opening of the twentieth century a great milestone loomed in the evolutionary progress of the treatment of fractures of the hip. Royal Whitman, of New York, gallantly revived an almost dying

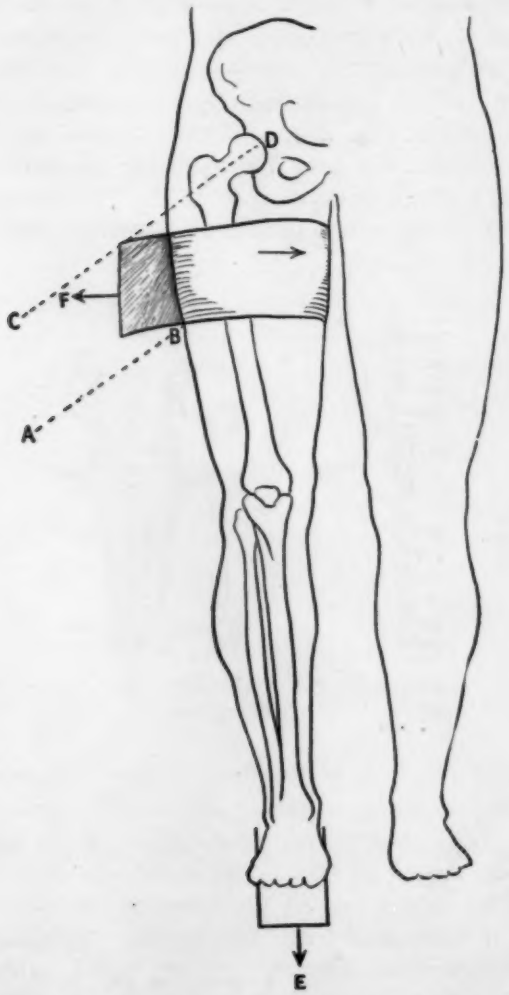

Fig. 20.—Maxwell-Ruth method of combined lateral and longitudinal traction. (From Wilson and Cochrane.)

interest in patients with such fractures and rekindled anew the flame that Ambroise Paré and Sir Astley Cooper had so enthusiastically borne in their trail-blazing efforts. In 1904 Whitman introduced the plaster of paris hip spica-abduction method of fixation, which was

to become for a time the accepted treatment all over the world. Bick, in his book on the History of Orthopedic Surgery, 1930, stated:

> Whitman's method has become a boon to the thousands of aged individuals, who, when treated by previous supportive measures had only the prospect of spending their few remaining years bedridden or in a wheelchair. He has succeeded in effecting rehabilitation of many of these cases, and among the more aged ones, has restored to a comparatively adequate function a limb which otherwise would have been entirely incapacitating.

In an article entitled the "Abduction Treatment of Fracture of the Neck of the Femur," appearing in *The Journal of the American Medical Association* of Dec. 3, 1921, Whitman stated: "The object of treatment of a fracture is to restore the symmetry of the broken bone, because the primary cause of nonunion is separation of the fragments and because deformity entails loss of function."

"The traction treatment is justified," he continued, "for fractures of the shaft of the femur but not of the neck of the femur. In the latter case the neck projects laterally and traction can at best appose the fragments in an insecure relation."

He stated further:

> In a recent treatise on fractures it is stated that the first indication is to save life, second to get union, third to correct or diminish displacements. This in fracture of the neck of the femur actually represents the subordination of surgical principles to inadequate mechanics. The abduction treatment is by contrast radical and revolutionary, because, being mechanically adequate for its purpose, fracture of the neck of the femur, in all operable cases, is treated like other fractures, in complete disregard of the qualifications and restrictions of conventional practice and of the conclusions that uphold it.
>
> The abduction treatment is adequate because it utilizes the anatomy of the hip joint both to correct deformity and to appose displaced fragments, external appliances being entirely subsidiary to the internal, or natural splint.

The Whitman method of treatment consists in reducing the fracture by direct traction of the leg longitudinally with the patient under anesthesia and abducting the injured limb, while traction is being applied, to the normal 45 degrees position and internally rotating the limb. This is done on a special fracture table, the Hawley table, with the pelvis supported on a pelvic rest. Two assistants then maintain both limbs in about 45 degrees of abduction. A plaster of paris spica bandage from the toes of the affected limb to the chest is applied over stockinet and a layer of sheet-wadding. Scudder, in his book, advised flexing the thigh according to Maxwell (in addition to Whitman's method of reduction) in order more readily to reduce the fragments. He considered Whitman's abduction method of treatment sound and declared that it was here to stay.

Cotton, shortly afterward, introduced the impaction method of treatment. In his book on fractures and dislocations, published in 1910, he stated (page 477, footnote):

> I believe the time is coming when it may seem wise, in these cases, perhaps in all unimpacted fractures of either neck or base of neck that are fit to etherize, to produce impaction by driving home the trochanter (protected by felt, of course) with a heavy mallet. I have done this in one case with admirable results.

Fred H. Albee, in 1912, introduced to this country the autogenous bone graft in the treatment of these fractures. Before describing this method, it may be better to take up again the early history of the employment of open operation. As has been noted, von Langenbeck, in 1858, was the first to attempt an operation, using a nail as the fixative agent. Then followed Koenig, in 1875, Trendelenburg, in 1878, and Lister, in 1880, all of whom used the nail (fig. 23). Trendelenburg and Koenig also advised suture of the bone with wire. Kocher in 1896 advised resection of the head of the femur. In 1897

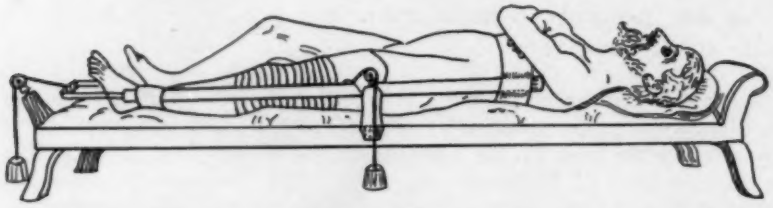

Fig. 21.—Longitudinal and lateral traction apparatus. This device includes a long wooden side splint, Buck's extension for longitundinal traction and a thick broad cloth band around the upper part of the thigh for lateral traction by means of a weighted cord attached to the band passing over a pulley. (From Phillips.)

Julius Nicolaysen reported on 13 cases of fresh fracture treated by means of a steel spike. He stated that when treated by this method the patient was immediately able to take up more comfortable positions. His technic consisted of applying manual traction on the affected limb and driving a steel spike 15 cm. long 5 cm. below the upper edge of the trochanter, so that the head of the spike remained outside the skin. A fenestrated plaster of paris spica was applied and maintained for eight to ten weeks. He did not allow weight bearing for ten or twelve weeks.

Pierre Delbet was the first to use the metal screw (fig. 24). He introduced this method in 1907. Dujarier and Delbet made extensive use of it. A heavy wormed metal screw 7, 8 or 9 cm. long and 6 cm. thick was employed. The screw was only partly wormed, so that an intimate opposition could be established. The screw was inserted about 1.5 cm. below the crista trochanterica. He placed 15 to 20

pounds (6.8 to 9.1 Kg.) of weight traction on both feet for a few days. Later he applied a walking splint for about four weeks.

While up to this time physicians performing internal fixation utilized metal as the fixative agent, F. Faltin stated that Hahn in 1909 was the first to use the bone peg from a tibial graft instead of the metal spike or screw. Borelius in 1911, reported a case of pegging.

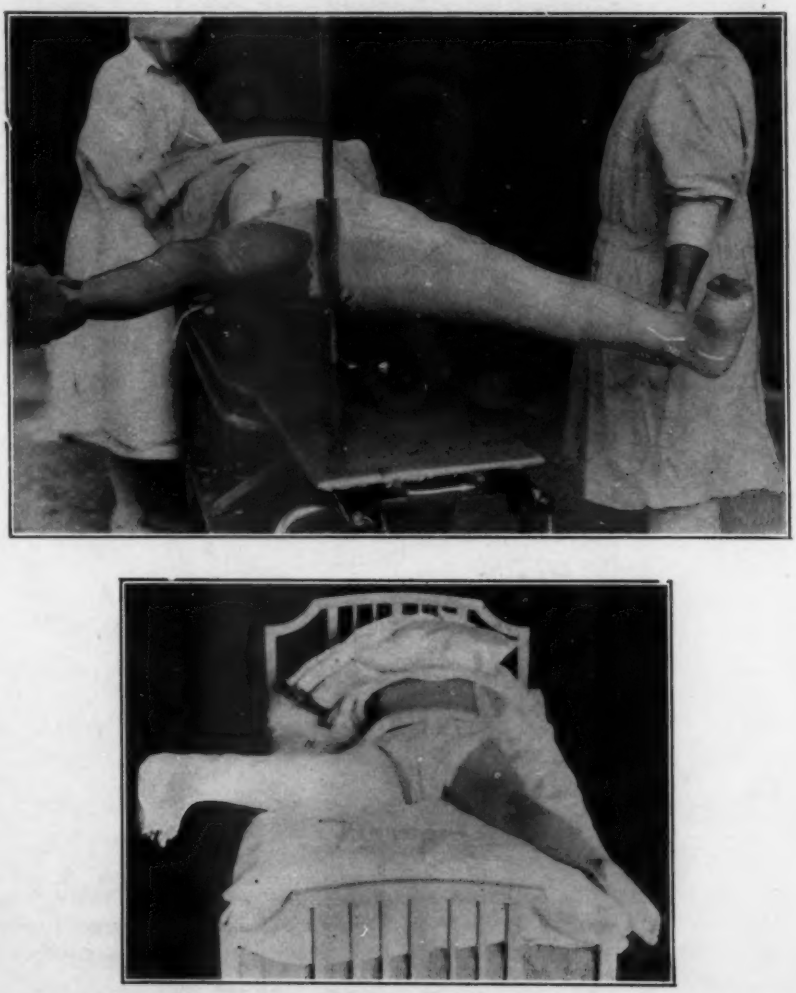

Fig. 22.—Whitman's method. Abduction in a plaster of paris hip spica bandage. (From Whitman.)

Fred H. Albee, of New York, employed the autogenous bone peg as the fixative agent for the first time, in 1912. Albee stated that the surgeon has the following obstacles to contend with in cases of this fracture, namely: (1) the mechanical disadvantage of not having

end to end stress as with other fractures; (2) deficient osteogenesis due to the presence of little or no periosteum and to a poor blood supply; (3) the intracapsular nature of the fracture and the possible detrimental effects of the synovial fluid present; (4) the interposition of soft parts, and (5) the relatively small diameter of the neck of the femur.

He therefore offered the autogenous bone peg as his method of treatment to overcome these obstacles. He stated:

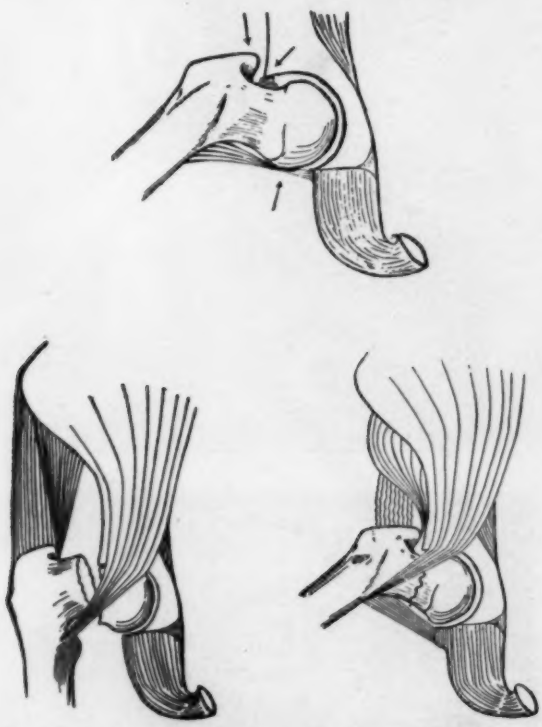

Fig. 22a.—Original diagrams from Whitman (1902).

A strong autogenous bone peg accurately fitted into a hole drilled longitudinally through the neck of the femur, with the fragments in good position, offers unquestionably, the most ideal condition for the rapid and satisfactory union, in good position, of this difficult fracture.

The following is the technic he uses (fig. 25):

1. The patient is placed on the Albee table.

2. A curved incision is made, beginning a fingerbreadth inside of the anterior superior spine and curved downward 3 to 5 inches (7 to 12.5 cm.) along the inner border of the sartorius.

3. The muscles are retracted; the point of fracture is exposed, and the interposed soft tissue, if any, is cleared from between the fractured ends, which are curetted and (if the fracture is old) freshened.

4. The limb is placed in abduction and traction.

5. A lateral incision is made over and below the greater trochanter, which is exposed.

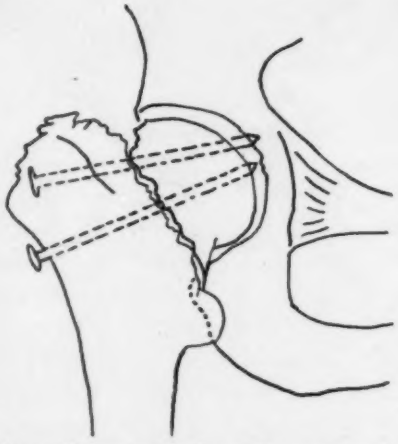

Fig. 23.—Two plain twelvepenny nails such as were formerly used in open operation for nailing the fragments together. (From Speed.)

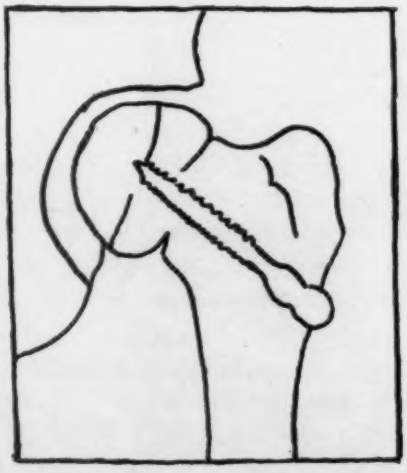

Fig. 24.—Delbet screw. (From Bassett.)

6. With a motor drill a hole ⅜ inch (0.9 cm.) in diameter is made.

7. A tibial graft which has been shaped into a peg by a dowel shaper is inserted into the drill hole and driven home.

8. The wounds are closed.

9. The limb is placed in the Whitman abduction plaster of paris spica extending from the toes to the midthoracic region.

10. Windows are cut in the plaster three weeks after the operation, and the wounds are dressed.

11. The long plaster spica bandage is kept on for six weeks and a short one for six additional weeks.

A graft from the fibula instead of the tibia was used as the bone peg for the first time by Delbet in 1911.

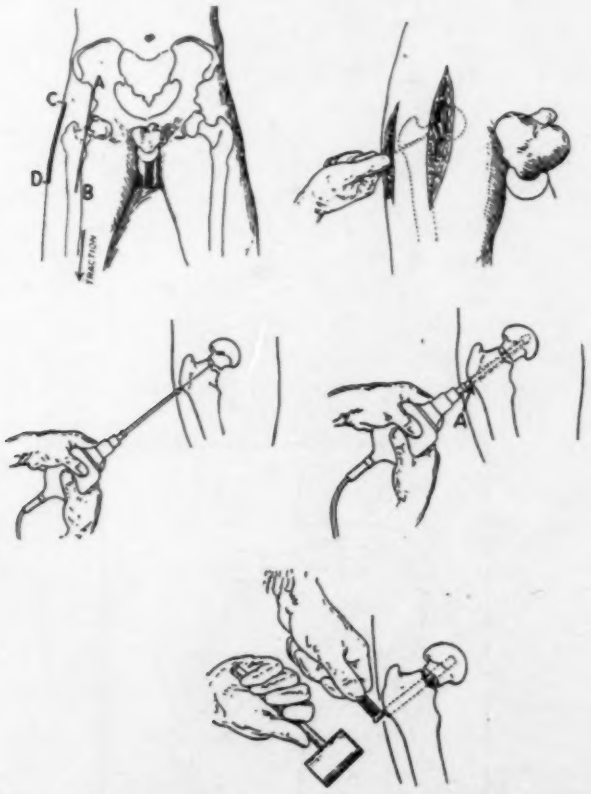

Fig. 25.—Use of the autogenous bone peg as the fixative agent. (From Albee.) *AB* and *CD* represent cutaneous incisions.

Ellis Jones in 1932 reported his experience with trochanteric transplantation of autogenous bone (fig. 26).

The advantages of the fibular bone graft over the tibial peg as claimed by Davison are:

1. It is the size of the bone adapted to the purpose.
2. The requisite length is easily obtainable.
3. It is irregularly round and will not rotate like a dowelled peg.

4. It is a tube of compact bone which is mechanically stronger than the same amount of compact bone in a solid piece.
5. It presents a continuous circular surface of the cambrium layer to the host bone for grafting and to simulate osteogenesis in and around the defect.

The operation is briefly described as follows:

With the patient on the Hawley table, an anterior incision, beginning a little below the anterior superior iliac spine and extending downward, is made, and the site of fracture is exposed. A second incision is made along the outer aspect of the thigh, exposing the greater trochanter. At an angle of about 45 degrees with the shaft of the femur an opening is made through the cortex with a gouge or electric drill. A canal is made, slightly smaller than the size of the fibular graft (a segment of the lower part of the fibula), and the graft is then driven home. A plaster of paris hip spica bandage is applied from the toes of the affected side to the axilla, including the opposite thigh. This is kept on for eight weeks, with the affected limb in extreme abduction, extreme external rotation and slight flexion at the thigh. Immobilization is maintained for eight weeks.

In the book "Autoplastic Bone Surgery" by Davison and Smith, published in 1916, there is a description of 3 cases in which this method was used. Mayo, Nordenbos and Kelvington have also used this method to a considerable extent.

E. H. Bradford in 1919 presented a method of ambulatory treatment by application of an abduction traction splint.

R. Hamilton Russell, of Melbourne, Australia, in 1924, reported a method of skin traction which he had been using for several years in such cases. It consisted of adhesive plaster (fig. 27) applied to the leg of the affected side as for Buck's extension, a sling made of toweling or felt in which the knee was placed and a system of pulleys so placed as to obtain a slight amount of flexion at the knee and yet effect traction. This is known as the Russell Traction.

O. P. D. Wilkie, of Edinburgh, Scotland, in 1927, described a method of abduction and immobilization of both legs by means of plaster bandages (fig. 28) to the latter. Again, the utilization of the principle of well leg extension was applied in a new method. Flexible copper cuffs were incorporated in plaster boots to each leg, with the sound leg in internal rotation and both legs in 45 degrees. Then a brass abduction rod was attached to the jointed attachments on the copper cuffs. Later a window was cut in the plaster of the sound limb so that the latter might be taken out and exercised from time to time.

METHOD OF SMITH-PETERSEN

An epoch-making era was ushered in, in 1925, when Smith-Petersen, of Boston, introduced his monumental contribution in this field. This consisted of an ingenious three-flanged nail which he used

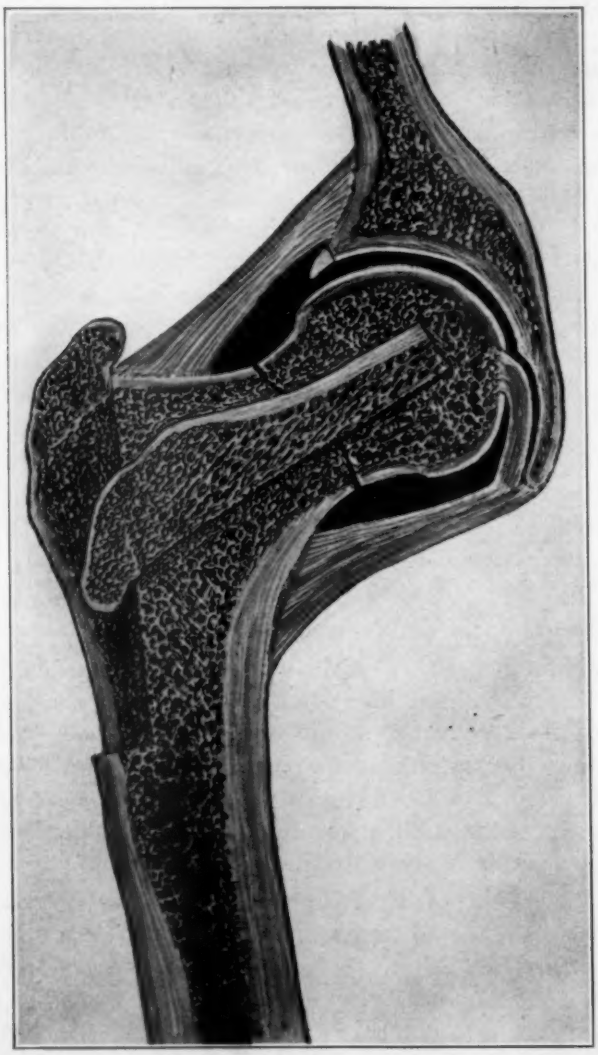

Fig. 26.—Trochanteric transplantation of autogenous bone. (From Ellis Jones.)

for transfixation of such fractures. While in the past two or three decades the Whitman plaster spica method had held sway as the method of choice, this new flanged nail pegging of the fractures has gained wide and rapid popularity.

The important feature of this operation lies in the shape of the nail. Its three flat blades are arranged cart wheel fashion and when inserted grip the bone firmly so that the bone cannot rotate about the nails on its axis. This renders fixation and approximation of the fragments more satisfactory. No postoperative agent of external fixation

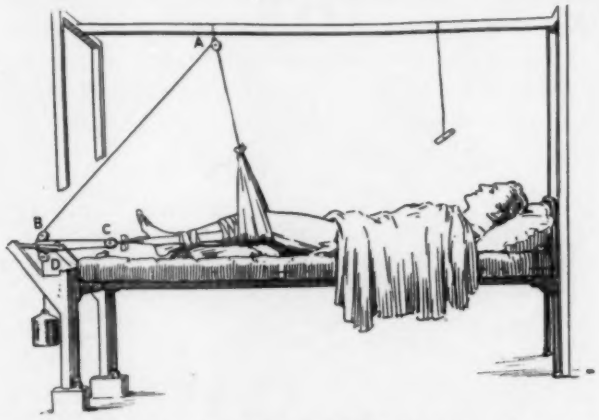

Fig. 27.—Traction with the knee in slight flexion. (From Russell.)

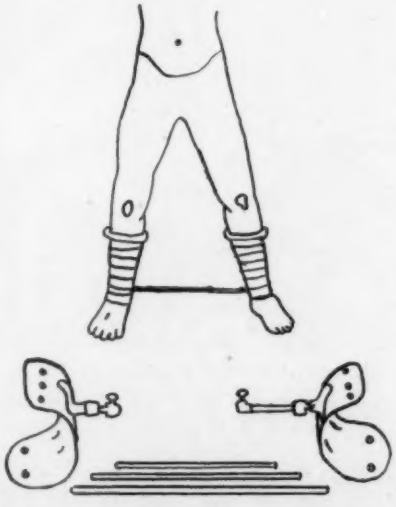

Fig. 28.—Abduction and immobilization of both legs. (From Wilkie.)

is necessary, because of the strength and security provided by the metal (stainless steel) nail. Early activity is allowed, convalescence is rendered more comfortable and is greatly shortened.

In November, 1931, Smith-Petersen, Cave and Van Gorder reported their description (figs. 29 and 30) of this operation. He made a curved incision along the crest of the ilium down the anterior

border of the tensor fasciae femoris, curving posteriorly across the insertion of this muscle into the iliotibial band in the subtrochanteric region. Then a musculoperiosteal flap was reflected from the dorsal aspect of the ilium, and the capsule of the hip joint was exposed. The fracture was reduced (after incision of the capsule) by internal rotation, extension and abduction of the limb. A point on the lateral aspect of the greater trochanter just below the attachment of the gluteus medius and the gluteus minimus muscles was located. About 1 inch (2.5 cm.) below this point, a starter the shape of the three-flanged nail, although heavier and stronger, was inserted with a mallet until the cortex was traversed. The starter was removed and the

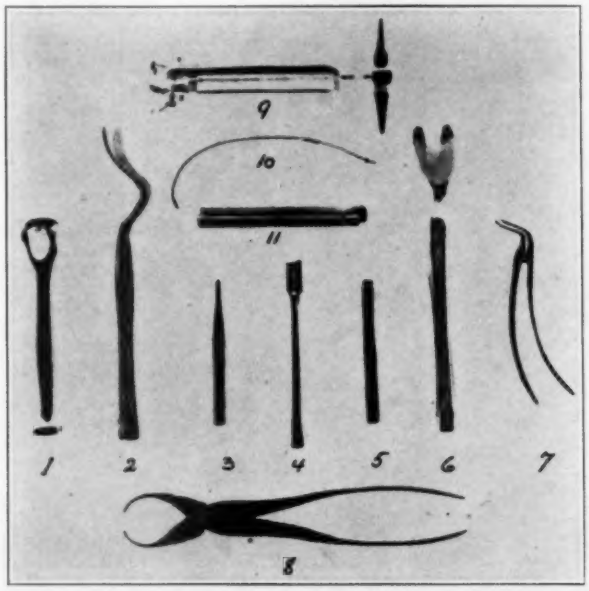

Fig. 29.—Instruments used for Smith-Petersen's operation: (1) impactor, (2) spatula, (3) nail-set, (4) starter, (5) nail-set, (6) spatula, (7) distractor, (8) obstetric forceps, (9) nail extractor, (10) flexible steel measure, and (11) three-flanged nail. (From Smith-Petersen, Cave and Vangorder.)

nail was introduced and tapped with a mallet until the head of the bone was pierced. At this point, the impactor, an instrument which impacts the two fragments by means of blows from a mallet, was used. (This instrument also assists in the progress of the nail into the head fragment.) The wound was closed in layers.

The postoperative management consisted of traction of 5 pounds (2.3 Kg.) for about three or four weeks. At the end of this time a bivalved short plaster spica in 10 or 15 degrees of abduction was used for walking only. [NOTE.—No external fixative agent is used at present.]

Weight bearing was allowed three to five weeks after the operation. Support in a plaster or jointed leather spica was used for from three to six months.

The results obtained in 20 cases reported by the author of this method showed osseous union in 15 cases, or 75 per cent; nonunion in 3 cases, or 15 per cent, and death from sepsis in 2, or 10 per cent.

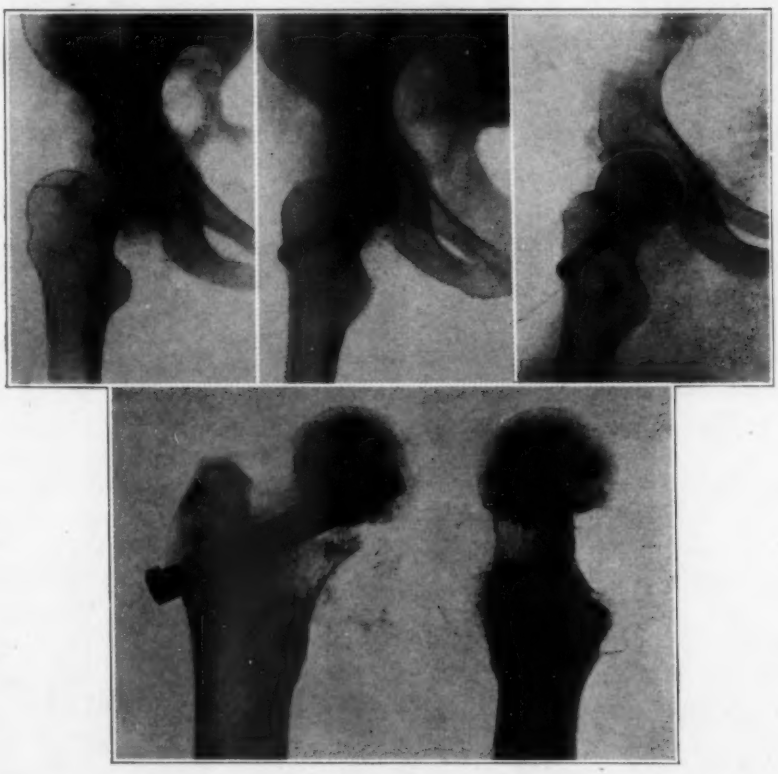

Fig. 30.—Preoperative roentgenograms and roentgenograms taken four and six weeks after operation. (From Smith-Petersen, Cave and Vangorder.)

He concluded that in the treatment of joint fractures, anatomic reduction and early function are the two outstanding principles.

In a later paper on this subject, which Smith-Petersen presented in October 1936, he described several modifications that he had employed in his more recent cases. Instead of the "open" method of operation which he used at first, whereby the hip joint was fully exposed, a formidable procedure to be sure, he had taken up the Wescott "blind-nailing" extra-articular method, which will be described later. He also had substituted the Wescott modification of the Smith-Petersen

nail, made of one piece of metal, for the type of nail previously used, which was made up of a headpiece welded on the shaft. The Leadbetter method of reduction, i. e., of flexion of the thigh, traction in the axis of the thigh and internal rotation, extension and abduction of the leg, had replaced the Whitman method, which he formerly employed.

Up to the time of publication of the second paper he had treated only 20 fractures by this new method and felt that the number of

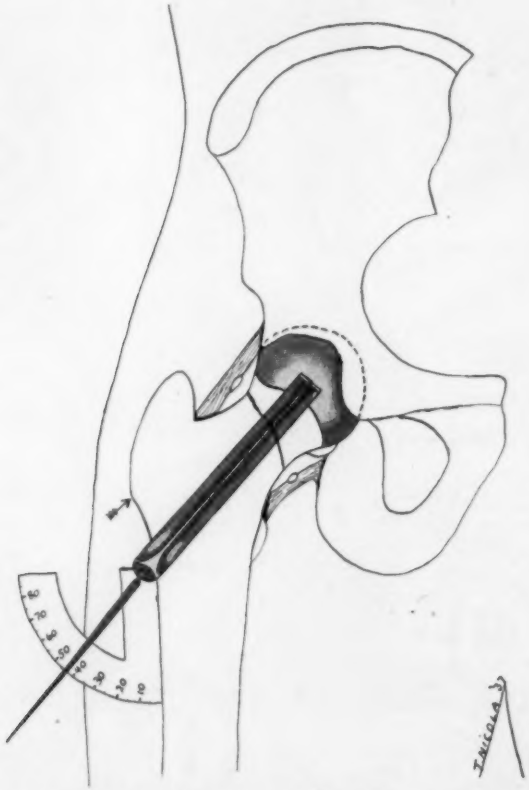

Fig. 31.—Technic of the Smith-Petersen operation. A nail is inserted 1 inch (2.5 cm.) below the base of the greater trochanter, as indicated by the arrow, at an angle of about 45 degrees, as shown by the protractor. Note the Wescott type of solid metal nail used instead of the former two-piece nail of Smith-Petersen.

cases as well as the time of observation was not sufficient to enable him to give a correct analysis of end results obtained by this method.

Sven Johansson, of Göteborg, Sweden, in 1932 used the same method as Smith-Petersen except that he used the "blind-nailing" type of operation (fig. 32). Instead of an extensive open operation

necessitating opening of the hip joint, Johansson inserted the nail "blindly" through a small lateral longitudinal incision over the greater trochanter; utilizing a Kirschner wire already inserted into the head and neck, he threaded the wire through a central canal in the nail as a guide.

Jerusalem, of Vienna, Austria, employed Johansson's method, using a nail with a hole bored through the head instead of a canalized one.

Wescott, of Roanoke, Va., in July 1932, reported a method (fig. 33) whereby he inserts the Smith-Petersen nail by the "blind" or extra-articular method. First he determines the angle of anteversion of the forward angle of the neck of the femur with the shaft by means of a roentgenogram. Then the length of the nail to be used is calculated by taking a roentgenogram of the normal hip with the leg in about 20 degrees internal rotation and a measuring rod strapped with adhesive tape to the trochanter. From the film the length of the neck is compared with the marks on the measuring rod, and thus the length of the nail is estimated. Also the angle of the nail with the shaft is determined.

Next the patient is anesthetized, and the fracture is reduced by flexing the thigh and exerting traction in the line of the thigh. Internal rotation is then performed. Abduction is not necessary, according to Wescott, because of danger of producing a valgus deformity. The assistant maintains the leg in internal rotation. Roentgenograms are taken to determine proper reduction.

A lateral incision of 2½ to 3 inches (6.2 to 7.5 cm.) is made over and below the greater trochanter. One-half inch (1.2 cm.) below the "vasternus line" narrow slits are made with an osteotome to receive the blades of the nail. The protractor is placed on the shaft of the femur with the lever placed on the angle already figured out. The nail is inserted and driven into the neck. The fracture is then impacted with an impactor. The wound is closed. Roentgenograms may be taken if it is desired to follow the course of the nail.

The patient is allowed in a wheel chair in from twenty-four to forty-eight hours and on crutches after a few days.

The nail fixation method has been also adopted by King, of Australia. He follows the Johansson method. The new Hawley table with the shock-proof fluoroscope and x-ray attachments is used as an aid in following the progress of the nail.

O'Meara, of Worcester, Mass., has used Wescott's method since 1933.

Roger Anderson, of Seattle, in 1932, revived the method (fig. 34 and 35) of utilization of well leg extension. The Brüninghausen, Gibson, and Hagedorn splints, and the Wilkie apparatus as previously described, employed the same principle of well leg extension, with the

exception that Anderson used skeletal traction on the injured limb, which traction was not used in the others. Brüninghausen also was among the first, if not the first, to obtain counterextension by means of well leg extension. In fact, Anderson stated in his article "that ancient history records the army mode of handling broken legs by pulling the injured leg to its normal length and bandaging it to the

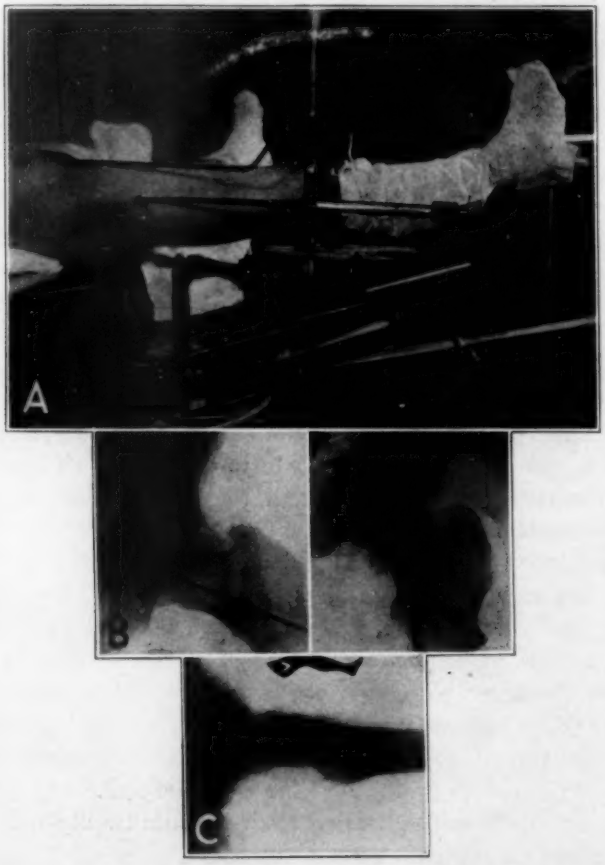

Fig. 32.—*A*, insertion of a Kirschner guide wire, followed by insertion of the Smith-Petersen nail; *B*, apparatus for accurate insertion of the Kirschner wire. (From Johansson.)

opposite or well leg in attempt to keep reduction and immobilization." He stated that C. K. Coonse and Carl P. Jones have also used the sound leg for both immobilization and countertraction.

The principle of Anderson's method is as follows:

If reduction of the fracture is made by traction in a parallel position to the sound leg and the well leg is maintained in a counter-extension, the x-ray shows

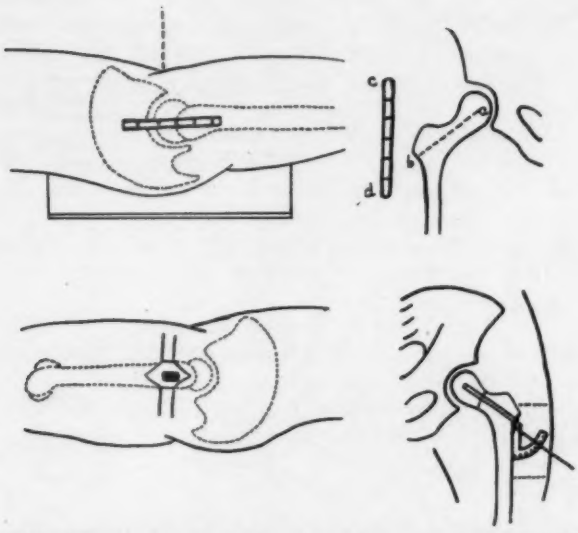

Fig. 33.—"Blind" or extra-articular insertion of the Smith-Petersen nail. (From Wescott.)

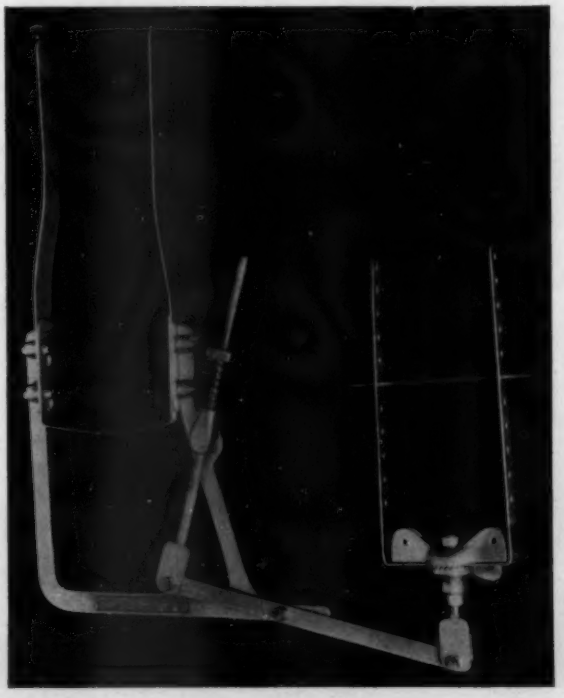

Fig. 34.—Splint providing skeletal traction on the injured limb. (From Anderson.)

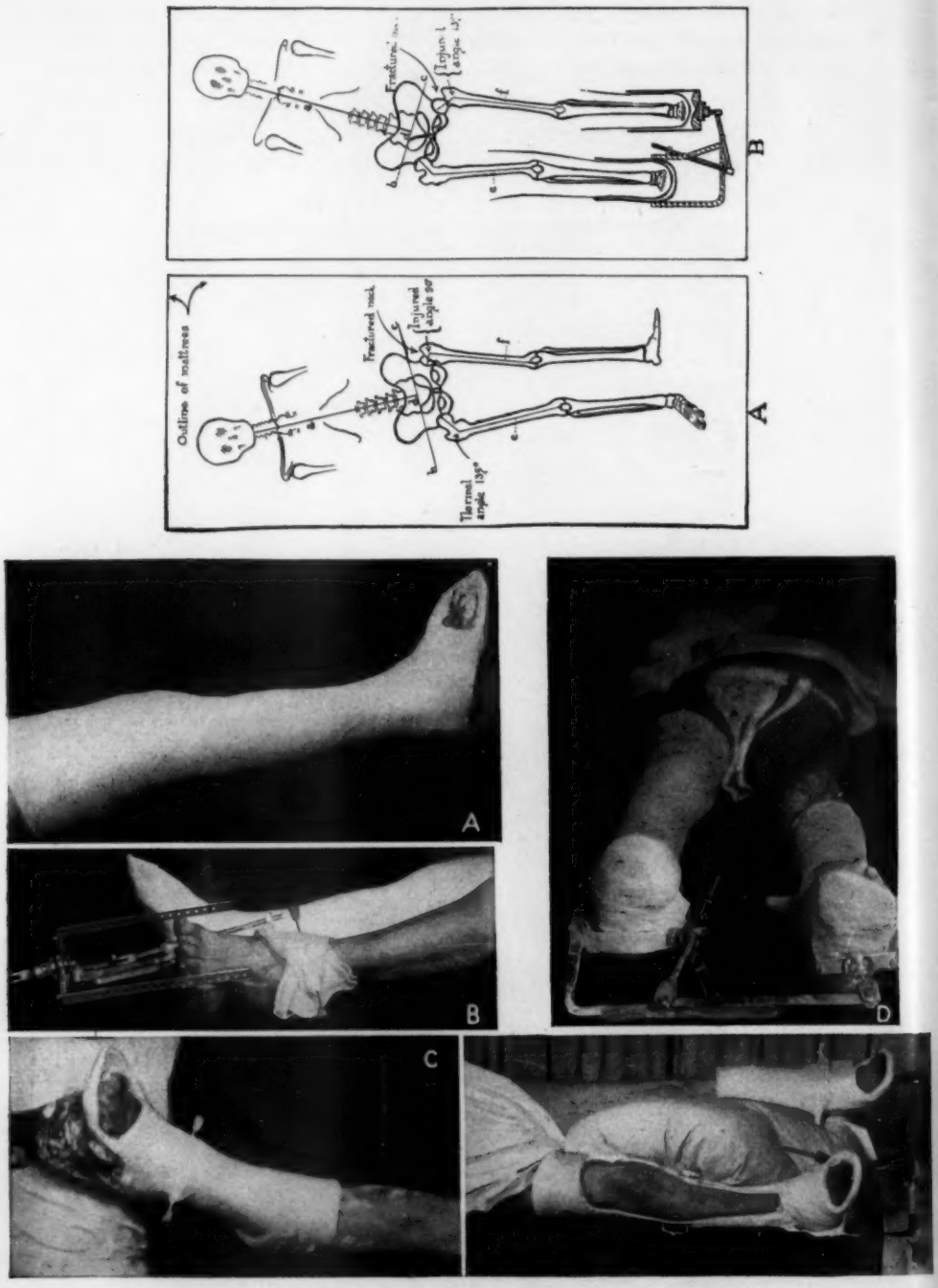

Fig. 35.—Treatment by skeletal traction. (From Anderson.)

that the traction forces the acetabulum down on the injured side, while counter-traction forces the well acetabulum up, thereby changing the angle of the transpelvic line with the axis of the injured leg, from an acute to an obtuse angle. This in turn forces the angle of the neck with the shaft of the injured femur into the normal position of 135 degrees.

The apparatus consists of a counter-traction portion and a traction portion. The former consists of a frame to which is attached a thin flexible counter-traction stirrup, with removable base to be molded later to the cast of the well leg.

A transverse lever which connects this counter-traction side to the traction part is pivoted to this frame, the axis of which is about six inches distal to the sole of the well foot. On a threaded traction rod which is joined to this end of the lever is a nut to furnish traction force, and a coiled spring to ensure a smooth, flexible, yet constant traction.

The traction portion of the splint is made up of a stirrup, with perforated sides for the insertion of the pin, and is connected to the lower arm by the traction rod, through the center of which at its proximal end is the rotation adjustment with its lock nut for internal and external stabillty.

The cause of nonunion of such fractures has been variously stated, interference with the circulation and improper immobilization having been prominently mentioned. It has been stated that with fractures of the neck of the femur ("intracapsular") the blood supply to the head portion is cut off because of the interruption of the nutrient artery from the distal portion of the neck and the capsular and periosteal arteries; also that arteriosclerosis causes an occlusion of the artery that courses through the ligamentum teres; this is a common observation post mortem. Therefore, Bozsan in 1932 attempted to remedy this situation by drilling holes through the trochanter and neck into the head fragment to establish circulation and promote osseous union. He reported 2 cases in which this method was used with good results.

The position of the leg both in the reduction of the fracture and in the maintenance of immobilization has long been the subject of considerable interest and attention. Hippocrates preferred to have fractures of the femur in extension; Rhages (850-932), on the other hand, of all the ancients was the only one to recommend the thigh to be laid "in a somewhat bent position." While it is not known whether the ancients were aware of the existence of fractures of the neck of the femur, still this shows that authorities differed in opinion as to the position of the limb in the presence of fractures of the leg, and this trend has continued up to the present day. Desault, Boyer, Hagedorn, Thomas, Ridlon, Liston and Whitman emphasized straight leg traction employed for either reduction or immobilization for fractures of the neck of the femur; Pott, Dupuytren, Cooper, Earle, Hodgen, N. R. Smith, Maxwell, Ruth, Russell, Leadbetter and Gaenslen, on the other hand, preferred a position varying from semiflexion to flexion of the hip and knee, with or without traction.

Leadbetter in 1933 devised a method of reduction of this fracture, which is known as the "Leadbetter method." Manipulation consists of flexion at the hip at 90 degrees with the thigh flexed at the knees at 90 degrees with the lower part of the leg. Manual traction is exerted in the axis of the flexed thigh, with slight abduction of the femoral shaft. The leg is then slowly circumducted into abduction, internal rotation and extension. The heel is allowed to rest in the palm of the examiner's hand to see if eversion of the foot takes place. If the neutral position of the foot is maintained with this test, reduction is then considered successful; this is known as the "heel-palm test." Then the limb is placed in a plaster of paris body spica bandage, with little padding. This method of reduction is becoming very popular.

Laurence Jones, of Kansas City, Mo., devised a closed double screw method for reduction and fixation of the fracture (fig. 36). He

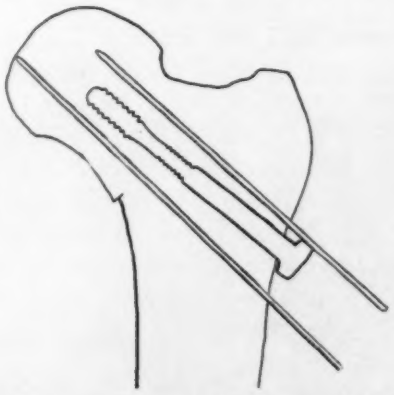

Fig. 36.—Closed double screw method for reduction and fixation of the fracture. (From Laurence Jones.)

reported this method in the *Annals of Surgery* in February 1933. The double screw consists of a proximal portion, a burr, a shaft with a square end for a socket wrench, and a traction cap with a groove for a screwdriver.

The procedure is as follows:

1. Measurement and localization of the fragments are done by means of roentgen examination.

2. Two Kirschner wires are inserted through the neck and head of the greater trochanter as guides and to keep the head fragment from rotating.

3. Plaster boots extending from the toes to 6 inches (1.5 cm.) above the knee are made preoperatively to prevent turning at the ankle; extension straps are placed over these, and the legs are maintained in the Whitman position.

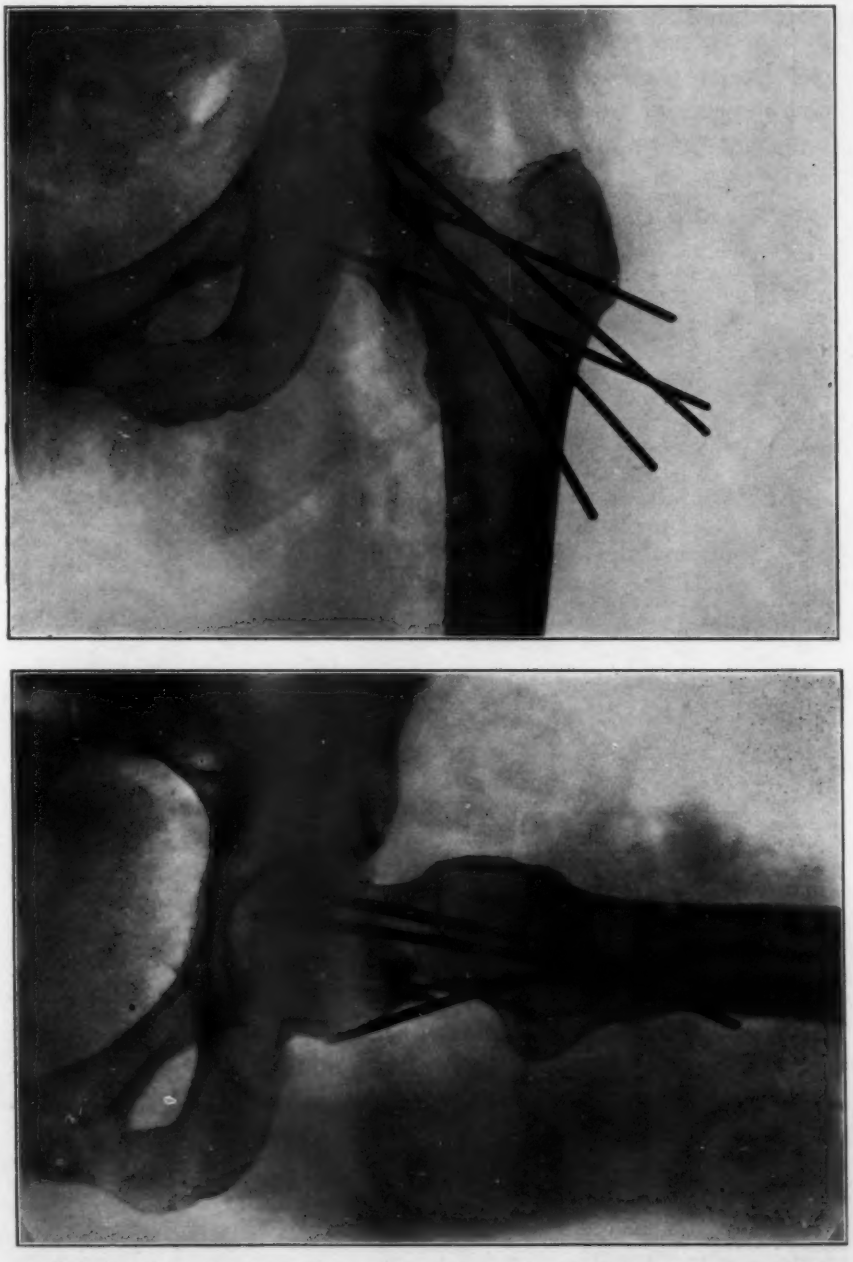

Fig. 37.—Insertion of rustless steel fixation spikes into the fragments. (From Gaenslen.)

4. Local or general anesthesia is employed.

5. A 2 inch trochanteric incision is made.

6. Kirschner wires are inserted.

7. Anteroposterior and lateral roentgenograms are taken to determine the position of the wires.

8. A drill hole is made between the wires, and the proximal portion of the screw is inserted with a socket wrench.

9. The distal or traction cap of the screw is threaded on the shaft of the proximal part and tightened with a screwdriver. The fragments are impacted with an impactor. A few more turns with the screwdriver are taken.

Fig. 38.—Fixation by means of several Kirschner wires. (From Telson and Ransohoff.) Picture on left, before reduction; picture on right, after first reduction and wiring.

10. No plaster bandage is applied, but a light pelvic brace is used. Baking and massage are instituted.

Earl D. McBride has adopted the use of the Whitman short spica with a Kirschner wire through the femoral condyles, incorporated in the plaster to give fixed countertraction. He described his method in 1933. Since then C. Percival Mills, of England, has described a similar method in the *Journal of Bone and Joint Surgery* of July 1935. He stated that the advantages of this method are: (1) easier reduction of the fracture and better control for the plaster of paris application; (2) greater comfort than is provided by the long spica; and (3) mobility of the knee and the ankle.

McBride has also used the Russell traction principle in cases in which confinement in plaster is not suitable.

Melvin Henderson, of the Mayo Clinic, in 1934 employed the blind nailing method, using the Kirschner wire as a guide. This procedure is similar to the method of Sven Johansson, as previously described, although it was devised independently and without knowledge of the existence of Johansson's method.

Fig. 39.—Method of taking lateral roentgenograms. A cassette is placed parallel with the longitudinal plane of the shaft of the femur. (From Johnson.)

Gaenslen in 1934 conceived the idea of inserting rustless steel fixation spikes, $\frac{3}{32}$ of an inch (0.3 cm.) in thickness, into the fragments subcutaneously at slight angles to one another (fig. 37). This is done with the affected leg abducted, at the level of the table, and internally rotated 10 to 15 degrees. Reduction of the fracture is obtained by

exertion of traction in the axis of the thigh, which is flexed at 90 degrees at the hip and knee. Then lateral pressure is applied over the trochanter and the leg is abducted to lock the fragments. Roentgenograms, anteroposterior and lateral, are taken. The spikes are introduced with the aid of hatpins around the greater trochanter for localization of the latter. Two Kischner wires are drawn through the fragments to steady them.

Posterior plaster shells to both legs, previously prepared, are utilized to support the legs on pedestals while the anteroposterior and lateral roentgenograms are taken.

Fig. 40.—Method of taking lateral roentgenograms, with use of a specially adapted curved cassette. (From George and Leonard.)

Telson and Ransohoff (1932) likewise have utilized steel wires in their internal fixation operation (fig. 38). Kirschner wires are inserted subcutaneously at different angles. The point of entry and distance at which each wire is inserted are predetermined. The only apparatus used while the patient is in bed is a short posterior splint at the ankle to prevent external rotation, especially for obese persons. The patient is allowed to sit in a wheel chair within a day or so.

Carl P. Jones in 1932 introduced a Jones traction splint as an aid to extension of the affected limb. Plaster of paris boots are applied to both legs, and the traction splint is incorporated in these boots. Then the traction lever is turned until the desired effect is produced. It is

the author's claim that there is 20 pounds (9 Kg.) of pull on the traction apparatus per ¾ inch (1.9 cm.).

In March 1936 Snodgrass proposed a treatment based on the anatomic factors involved in this fracture. The principle that he advised was adduction and external rotation of the limb, maintained

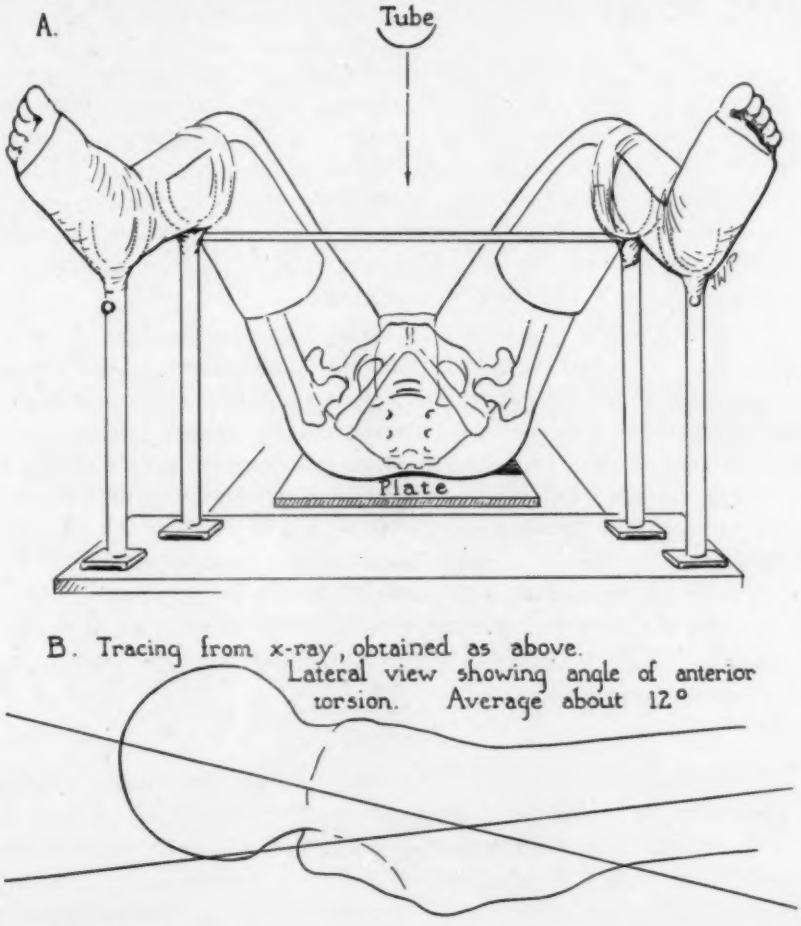

Fig. 41.—Another method of obtaining lateral roentgenograms. "Without moving the patient, it is possible to slip a plate under the buttocks and to obtain a lateral view of the affected hip." (Gaenslen.)

by a plaster spica. He reduced the fracture by traction, external rotation and anterior lifting of the thigh. He stated that after the fracture was reduced, the fascia lata, being placed on a tension by the adduction position of the limb, forcibly maintained impaction of the fragments by exerting constant pressure on the greater trochanter.

ROLE OF ROENTGEN RAYS

The advances made in the field of roentgenology have played an important part in the forward progress of the care of the "broken hip."

Tribute must be paid to Roentgen, who in 1895 introduced to the medical world the successful use of the x-ray apparatus. Added impetus was given by this new aid in the proper handling of these fractures.

At first the simple anteroposterior view was used exclusively. Of late years, however, the lateral roentgenogram has come into great vogue. This is largely because in many cases, although the anteroposterior film shows an apparently satisfactory apposition of the fragments, the lateral view shows a displacement, such as an open V anteriorly or posteriorly, or an end to side approximation; i. e., the fractured surface of the head fragment may lie against the posterior surface of the neck fragment, or vice versa.

In 1932 Clayton Johnson and George and Leonard at about the same time developed a technic for taking lateral views. They attained the same end in a different manner. Clayton Johnson placed a cassette (fig. 39) parallel with the longitudinal plane of the shaft of the femur, and the central rays projected from a point over the opposite thigh toward the affected hip joint at an angle of 25 degrees with the transverse plane of the femoral shaft. George and Leonard on the other hand (fig. 40), utilized a specially adapted curved cassette placed in the crotch, the central rays emanating from a point just to the side of the patient's head and directed toward the affected hip and cassette.

Gaenslen and O'Meara also contrived methods of their own (fig. 41) for obtaining lateral views.

SUMMARY

In this historical survey I have tried to trace the various methods employed in the treatment of transcervical fractures of the neck of the femur from the time of Ambroise Paré (1510-1590) to the present time. I have observed that the ancients (Hippocrates, Celsus, Galen, Avicenna and others) left no evidence of their knowledge of the existence of such a fracture. In his account Ambroise Paré brought attention to this fact very clearly. He pointed out how, in all probability, as he himself had been guilty of doing previously, physicians had wrongly diagnosed all such fractures and had treated them as dislocations of the hip.

If Ambroise Paré is to be accepted, then, as the first to recognize and distinguish fracture of the neck of the femur as a distinct surgical entity, the honor and credit of being the pioneer in the handling of this

most perplexing of fractures are due him. His attempt to treat the condition was crude and inefficient, consisting simply of applying splints and compresses with a hip spica bandage over them and about the affected hip joint. His aim, of course, was to maintain the fragments in place and immobilize the hip joint as much as possible.

It has been observed how the various fundamental principles in the treatment of fractures were applied; how new, specially adapted ones were discovered; how old ones were revived or modified, and how combinations of them were utilized. It is noted how one by one they were discarded, either because of ultimate failure or because of the suffering and discomfort experienced by the patient.

In reviewing the various methods, it is noted that many of them can be classified, e. g., splint immobilization, extension-counterextension, positions of semiflexion, abduction–internal rotation or adduction.

The following outline is an attempt to group these methods:

METHODS OF TREATMENT AND PRINCIPLES INVOLVED

I. Splints
   1. Short splints maintained in place by a spica inguinalis bandage (Ambroise Paré, 1510-1590)
   2. Desault splint-permanent extension
   3. Thomas-Ridlon (1888), posterior hip brace
   4. Bradford (1918) ambulatory abduction splint

II. Extension-counterextension methods
   1. Girt of Fabricius Hildanus (1537-1619)
   2. Jean-Louis Petit (1679-1750) extension-counterextension
   3. Thomas ring splint with Buck's extension (1888)
   4. Liston splint and Buck's extension
   5. Well leg extension principle
      (*a*) Brüninghausen?
      (*b*) Gibson-Hagedorn Modification of Brüninghausen's method (1860)
      (*c*) Wilkie splint (1927)
      (*d*) Roger Anderson splint (1931)
      (*e*) Jones traction splint (1932)

III. Semiflexion position with or without traction
   1. Pott (1713-1788) Semiflexion position and no traction
   2. Double inclined plane; no traction
      (White, of Manchester, England, is said by Astley Cooper to have first advocated this.)
   3. Sir Astley Cooper's method (1768-1841)—simply a pillow under the knee
   4. Earle's bed (1828) principle of double inclined plane
   5. N. R. Smith (1867) suspension splint
   6. Russell traction (1924)

IV. Principle of flexion at hip and knee
  A. Applied in Reduction
    1. Dupuytren (1777-1835)
    2. Scudder
    3. Ruth (1891)
    4. Moore (1912)
    5. Leadbetter (1933)
    6. Gaenslen (1932)
  B. Applied in Fixation
    1. J. A. Moore (1912), plaster abduction and flexion at the hip
    2. Gaenslen (1934), plaster abduction and flexion at hip plus internal spike fixation

V. Principle of abduction
  1. Whitman (1904) abduction by the plaster of paris spica method
  2. E. H. Bradford (1918) abduction with ambulatory splint
  3. Russell traction (1924)
  4. Leadbetter (1933)
  5. Wilkie (1927)
  6. Roger Anderson (1931)

VI. Principle of adduction
  1. Snodgrass (1936)

VII. Distention
  1. Gooch (?-1780)
  2. Aitken (?-1790)
  3. Earle D. McBride (1933)

VIII. Lateral pressure on greater trochanter
  1. Pott
  2. Desault
  3. Senn (1889)
  4. Scudder (at one time Scudder advocated Thomas-Ridlon splint with Senn's lateral pressure)

IX. Impaction
  1. Cotton (1910)
  2. Smith-Petersen (1925)

X. Lateral and longitudinal traction
  1. Maxwell (1871)
  2. Ruth (1891)

XI. Multiple drill holes
  1. Bozsan (1932)

XII. Dextrinized splint (hip spica bandage)
  1. Velpeau (1841)

XIII. Plaster of paris bandage
  1. Senn (1889)
  2. Whitman (1902)

XIV. Internal fixation
  1. Metal nail
    (*a*) Von Langenbeck (1858)
    (*b*) Koenig (1875)
    (*c*) Trendelenburg (1878)
    (*d*) Lister (1880)
    (*e*) Lemon (1913)
    (*f*) Smith-Petersen (1925) three-flanged nail
    (*g*) Wescott (1932)
    (*h*) Sven Johansson (1932)
  2. Wires
    (*a*) Gaenslen (1932)
    (*b*) Telson and Ransohoff (1932)
  3. Autogenous Bone Peg
    (*a*) Delbet (1911) fibular bone peg
    (*b*) Albee (1912) tibial bone peg
    (*c*) Ellis Jones dowel peg from greater trochanter
  4. Screws
    1. Delbet screw (1907)
    2. Laurence Jones closed double screw (1933)
    3. Myron Henry screw bolt (1934)

XV. No treatment (except sandbags)

CONCLUSION

In review, it may be seen that the evolution of the treatment of this type of fracture has been slow and arduous. New principles or devices seldom have been successful.

Improvements of any importance have been few and far between. It is only within the memory of many living surgeons, within the last thirty or forty years, that the greatest progress has been made in this field.

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ARTERIAL OCCLUSION WITH ASEPTIC NECROSIS OF BONE

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An adequate blood supply is necessary for the nutrition of bone tissue. Complete interruption of the circulation causes infarction or aseptic necrosis.[1] The extent of such a circulatory disturbance determines the amount of necrosis in a bone, although impeded or interrupted circulation does not affect equally all bone tissue. According to Haslhofer,[1] Axhausen and Bergmann [1] and Müller,[2] diminished blood supply causes necrosis of portions of the bone tissue while the marrow structures remain intact. The statements of these authors emphasized that bone as a tissue is readily damaged by obstruction of the circulation, a view in marked contrast with the older opinion that the great vascularity of bones precludes infarction. Burckhardt [3] shared this view and concluded that excessive stress of the bands carrying the nutrient vessels to bones or a direct break in the continuity of the nutrient blood supply would cause a serious local injury of the bone. He observed the formation of new bone only when the marrow and periosteum were injured. Damage to the periosteum and marrow, he stated, constitutes a stimulus to regeneration rather than to necrosis of the ground substance of the bone. The vessels supplying blood to the diaphyses of long bones are, according to Johnson,[4] in the order of their importance: (1) nutrient vessels piercing the cortex, which maintain the viability of the medulla and supply the inner half of the cortex; (2) metaphysial

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1. The comprehensive reviews by G. Kistler (Sequences of Experimental Infarction of the Femur in Rabbits, Arch. Surg. **29**:589 [Oct.] 1934; Effects of Circulatory Disturbances on the Structure and Healing of Bone: Injuries of the Head of the Femur in Young Rabbits, ibid. **33**:225 [Aug.] 1936) and those published more recently by L. Haslhofer (in Henke, F., and Lubarsch, O.: Handbuch der speziellen pathologischen Anatomie und Histologie, Berlin, Julius Springer, 1937, vol. 9, pt. 3) and G. Axhausen and E. Bergmann (in Henke, F., and Lubarsch, O.: Handbuch der speziellen pathologischen Anatomie und Histologie, Berlin, Julius Springer, 1937) contain most of the important literature references on this subject.

2. Müller, W.: Beitr. z. klin. Chir. **138**:614, 1927.

3. Burckhardt, H.: Beitr. z. klin. Chir. **138**:625, 1927.

4. Johnson, R. W., Jr.: J. Bone & Joint Surg. **9**:153, 1927.

vessels, which penetrate the cortex to supply the marrow and the inner half of the cortex, and (3) periosteal vessels, which nourish the outer half of the cortex and have a limited capacity as a source of collateral circulation.

The fate of bone aseptically necrotic because of disturbances in circulation varies considerably. According to Phemister,[5] when the necrotic bone is closely united with living bone, fibrous and osteogenic tissues grow from the living into the necrotic bone, and by creeping substitution the old bone is gradually absorbed and replaced by new bone. The degree of restitution, he stated, depends on several factors, such as functional stimulation, anatomic location and the quantity of contiguous living bone. To these should be added adequacy of the blood supply and ability of the tissues to revascularize the dead portions. A comprehensive summary by Rohde[6] emphasized the importance of the role of the vascular system in the entire process of bone regeneration. The intactness of the blood supply and the ability of the blood to react, he stated, determine regeneration. When the circulation is maintained, the fracture hyperemia persists sufficiently, and bone regeneration occurs from surviving osteoblasts. Damage of the blood supply by the initial injury or subsequently in the process of regeneration results in a growth of scar tissue at the expense of bone, from the constituents of the bone or from the surrounding tissues. Complications of the restitution process develop when functional activity causes impression or compression fractures of the bone tissues affected and additional injury to the nutrient arteries or their intrinsic branches.

Disturbances in nutrition are accepted generally as the cause of aseptic necrosis of bone. Various opinions have been expressed, however, concerning the cause of such disturbances (except those produced by chemicals, by irradiation, or by some other obvious specific cause). In an argumentative analysis of the pathogenesis of nonspecific aseptic necrosis (spongiosa disease) of bone, Block[7] concluded that vascular disturbances account for only a few lesions. More probably, he argued, the nutritional disturbances depend on colloidal and chemical alterations of the spongiosa, changes in the blood vessels being incidental. Block conceded that vascular occlusion would provide the simplest explanation for the nutritional disturbances but stated that he is unacquainted with evidence of occluded or narrowed blood vessels. Haslhofer[1] regarded ischemia as the fundamental factor in causation of nonspecific aseptic necrosis of bones, but the cause of this vascular interference is not clear. He considered Axhausen's theory of embolic infarction improba-

5. Phemister, D. B.: J. Bone & Joint Surg. **12**:769, 1930.
6. Rohde, C.: Arch. f. klin. Chir. **123**:530, 1923.
7. Block, W.: Arch. f. klin. Chir. **174**:172, 1933.

ble and supported the opinion of Kienbock, who concluded that nutrient vessels of bones are injured by trauma often considered insignificant by the patient. Cordes [8] concluded that aseptic necrosis of the os lunatum of the wrist always is due to a fracture, the extent of necrosis being dependent on the severity of the injury. Legg-Perthes' disease and aseptic necrosis of other bones, he stated, are caused by interruption of the blood supply. There can be no sharp distinction between the two processes, for when fracture occurs, blood vessels are injured; and the extent of damage to them, as Rohde emphasized, determines largely the subsequent healing processes. Novotny [9] considered circulatory disturbances the most important cause of aseptic necrosis of the metatarsal bones (Köhler's disease). Such disturbances occur, he stated, when unusual movements or traumas injure the nutrient arteries carried in the collateral bands of the metatarsophalangeal joint and thus interrupt the blood supply to the head of the metatarsal bone.

Although many authors accept disturbances in nutrition as fundamental in aseptic necrosis of bones, the basic factors causing such a disturbance seem to have been postulated rather than subjected to study. Axhausen's theory of embolic infarction is attractive, yet the demonstration of such vascular occlusions in the human being has not been accomplished. Supporting evidence has been found, however, in experiments on animals.[1] Block, conceding the simplicity of vascular occlusion as a cause for aseptic necrosis of bone, said that he was unacquainted with evidence of occluded or narrowed blood vessels. Perhaps opportunities to study changes in nutrient arteries leading to regions of aseptically necrotic bone tissue have been disregarded or not fully utilized. Occlusions or constrictions of nutrient arteries associated with aseptic necrosis of bone tissues, however, are the main theme of this report.

REPORT OF CASES

CASE 1.—A white man, aged 54, a crane operator, entered St. Luke's Hospital on Nov. 26, 1937, because of pain and limited mobility of the left wrist. On August 7 he had fallen about 30 feet (9 meters) to the ground. Among other injuries was a fracture of the left wrist. After one week in a splint the left wrist was incised and a bone was removed. On November 27 pieces of articular cartilage and cancellous bone were removed through an incision of the old scar. The report on a roentgenogram taken on November 29 recorded the loss of parts of some of the small bones of the wrist and a dislocation of the semilunar bone. This bone was removed by Dr. Harry E. Mock on December 7. It was 2.5 by 2 cm. across the convex articular surface and was 1.8 cm. thick. The cartilage of the concave articular surface was glistening; that of the convex surface had lost its smoothness, and the bone tissues beneath were friable.

8. Cordes, E.: Beitr. z. klin. Chir. **149**:28, 1930.
9. Novotny, O.: Arch. f. klin. Chir. **190**:604, 1937.

The bone was fixed in Zenker's solution, hemisected and embedded in pyroxylin. The sections, stained with hematoxylin and eosin, were examined for changes in the large nutrient arteries. A large nutrient artery in one block entered the bone tissues in a mass of edematous scar tissue. The original lumen (fig. 1*A*) was reduced to a narrow slit by an intimal thickening of fibroblastic tissue containing a

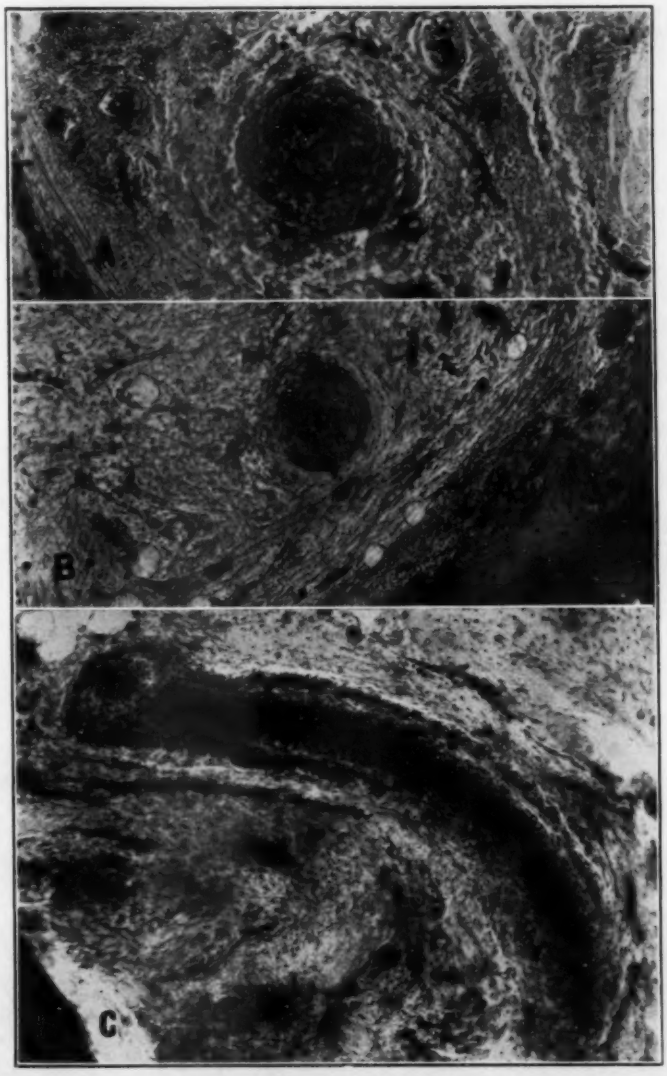

Fig. 1.—*A*, photomicrograph (× 88) illustrating the fibrous tissue thickening of the intima and obliteration of the lumen of a nutrient artery extending into the lunate bone (case 1). *B*, photomicrograph (× 88) of a branch of a nutrient artery with a thickened wall and a small lumen, embedded in fibrous tissues that have replaced portions of the bone (case 1). *C*, photomicrograph (× 88) of a nutrient artery extending into the lunate bone, illustrating the fibrous tissue thickening of the wall and the greatly reduced lumen (case 2).

few polymorphonuclear leukocytes. The walls of several small arterial branches (fig. 1 *B*) at other levels in this fibrous tissue showed similar changes. The marrow fat was mixed with fibrous tissue. The articular cartilage was intact, but beneath it were broken fragments of necrotic bone trabeculae. There was no reactive bone tissue. The artery channels deep in the bone showed dilated lumens filled with blood cells. The marrow fat was extensively replaced by fibrous tissue.

Case 2.—A white man aged 37, a laborer, entered St. Luke's Hospital on Dec. 7, 1937, because of pain and flexion immobility of the left wrist. On March 13, his left hand, slipping on a pump handle, had been forced into sharp dorsal extension. Flexion of the wrist and the stress of a weight caused pain. Three weeks before his admission, a roentgen examination demonstrated a volar dislocation of the os lunatum. Dr. W. R. Cubbins explored the tissues on the day of the patient's admission to the hospital and removed the dislocated bone because it could not be replaced. The convexly curved articular surface was 2.3 by 1.8 cm. The thickness of the bone was 1.7 cm. The cartilage of both articular surfaces had lost the usual gloss, and portions were roughened by fibrous tissue.

The marrow fat was replaced by fibrous tissue. Large portions of the bone, cartilage and marrow tissue were necrotic. A large nutrient artery had thick fibrous walls and a compressed, narrow lumen (fig. 1 *C*). Arterial branches with constricted lumens were embedded in dense scar tissue.

Case 3.—A white man aged 41 entered St. Luke's Hospital on Jan. 18, 1937, because of a swollen, painful left wrist. On Oct. 7, 1936, a package of newspapers had been thrown to him, the impact hyperextending his left hand. The hand could be flexed but not extended at the wrist. Lateral flexion was slight; medial flexion was absent. Roentgen examination disclosed necrosis of part of the os naviculare. Dr. Charles Drueck Jr. removed the bone on January 8. It was irregular, 2.5 by 1.5 by 1.3 cm., with portions broken away. The broken surface, mainly on one end, was 1.5 by 1.2 cm. The surface of the articular cartilage was smooth and glistening. Two other pieces of bone were 1.2 by 1 by 0.8 cm. and 1 by 0.8 by 0.6 cm. respectively.

The articular cartilage had the usual structure. The bone tissue beneath showed no changes, except the portion which showed decreased density in the roentgenogram (fig. 2 *A*). This was necrotic. The narrow spaces along the margins of this region contained edematous fibrous and fatty tissue. Deep in the marrow tissue and extending toward the necrotic region was a large nutrient artery with thick, muscular walls. The lumen of this vessel (figs. 2 *B* and 2 *C*), traced in interrupted serial sections, contained a fibroblastic tissue thrombus that filled all but a narrow edge of the lumen.

Case 4.—A white man aged 27 fell on his extended right hand on Dec. 12, 1933. His wrist became swollen and painful. Partial immobilization gave no relief. He continued to work, but with discomfort; at times, pain at night was sufficient to keep him awake. Flexion and extension of the right wrist were considerably restricted; pronation and supination, slightly. Roentgen films disclosed fragmentation of the os lunatum. On Sept. 30, 1934, Dr. W. F. Lyon removed the lunate bone in several pieces. It was misshapen; it measured 1.2 by 1 cm. and was 1.6 cm. thick.

The concave articular surface had a narrow edge of hyaline cartilage. The flattened convex edge was covered by dense fibrous tissue; only a few small masses of hyaline cartilage remained. Dense fibrous tissue replacing portions of the bone contained many broken and necrotic fragments of bone trabeculae (fig. 2 *D*). There

was a slight reaction about some of the cartilage and bone fragments. The marrow spaces of the bone adjacent to the scarred portions contained edematous fibrous tissue or fibrous and fatty tissue. The nutrient arteries and their branches had small lumens and thick muscular and fibrous walls.

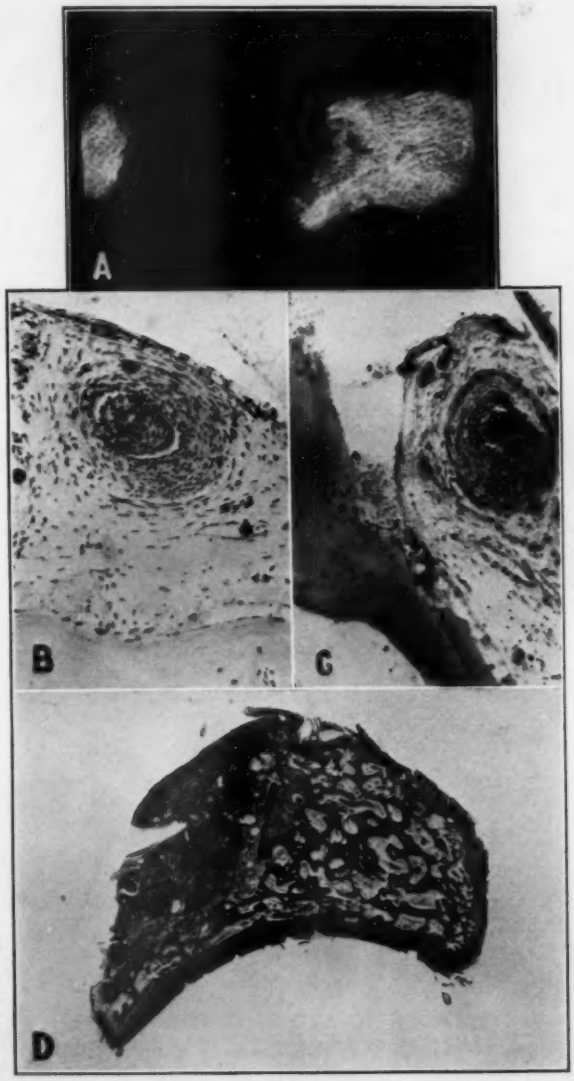

Fig. 2.—*A*, roentgenogram of the excised os naviculare, illustrating the changes in osseous texture (case 3). *B*, photomicrograph (× 88) illustrating the organizing thrombus in a branch of a nutrient artery at the edge of the necrotic bone tissues (case 3). *C*, photomicrograph (× 88) of one of the interrupted serial sections, illustrating the occluding thrombus at a level where it contained erythrocytes, leukocytes and organizing granulation tissue (case 3). *D*, photomicrograph (× 88) of a section of the os lunatum, illustrating the necrotic portions and the portions replaced by fibrous tissue (case 4).

CASE 5.—A white youth aged 16 had been in excellent health until six months before his admission to St. Luke's Hospital on March 31, 1937. At that time he had fatigue and weakness of the left thigh, symptoms which he thought appeared after he had been kicked in this region. At the time of the presumed accident the

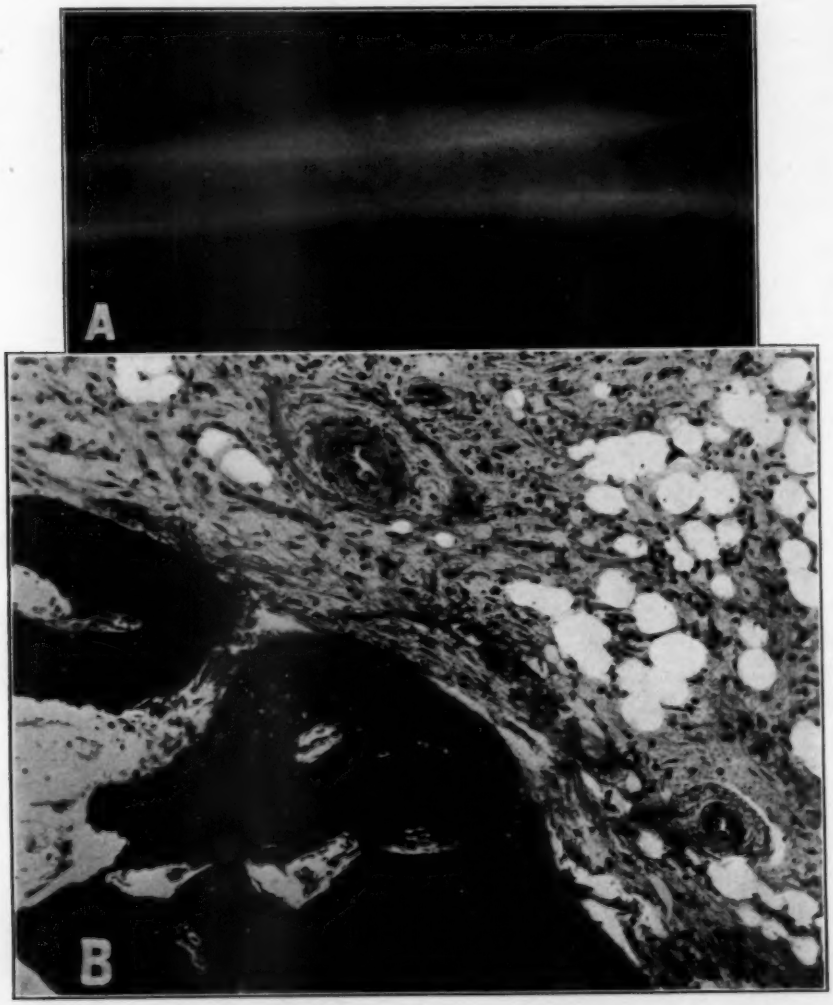

Fig. 3.—*A*, roentgenogram illustrating the thickening of the cortex of the shaft of the femur (case 5). *B*, photomicrograph (× 124) illustrating the fibrous tissue invasion of the medullary tissues, arterioles with small lumens, and bone. Some necrotic trabeculae had new bone deposited along the margins (case 5).

tissues were not discolored or painful. After three months he had sharp pains in the middle of the left thigh, which radiated to the ankle and at night were sometimes severe enough to keep him awake. A slight limp developed. Roentgenograms (fig. 3*A*) of the thigh disclosed thickening of the cortex above the middle of

the femur. Some regarded this thickening to be due to low grade osteomyelitis or to a neoplastic growth. On April 1 Dr. W. R. Cubbins exposed the cortex of the femur opposite the junction of the upper and middle thirds of the bone. The surface was roughened and elevated for about 8 cm. by sclerotic bone. The bone

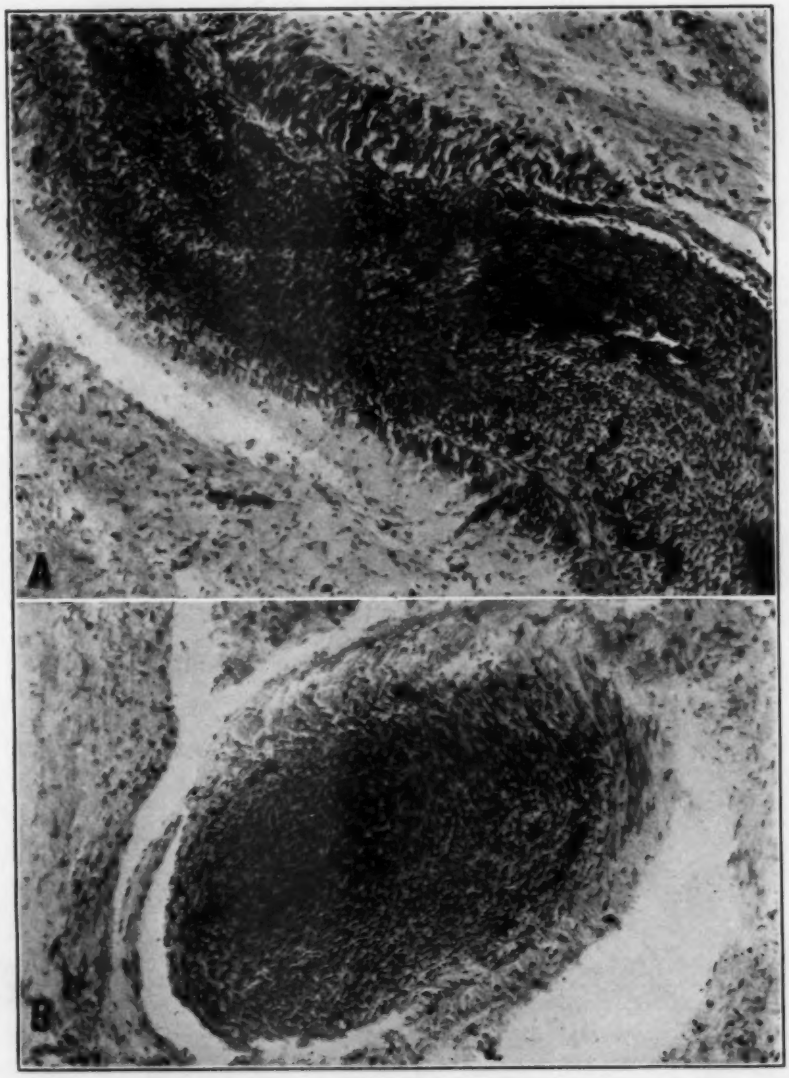

Fig. 4.—*A* and *B*, photomicrographs (× 103) illustrating the fibrous tissue thickening of the wall and collapse of the lumen of a nutrient artery associated with the bone lesion (case 5).

tissue was sclerotic and pale; the periosteum was intact and easily detached. After the thickened cortex had been removed, the marrow was found to be soft red tissue. Cultures of this tissue were sterile. The cortex of the medial side of the bone was pale and more dense than normal.

The marrow tissues removed contained necrotic bone trabeculae, some with margin layers of newly formed compact bone (fig. 3). The fat in the marrow spaces was replaced by fibrous tissue. Branches of the nutrient arteries had thick walls and small lumens. Some of the trabeculae of the cortex were necrotic,

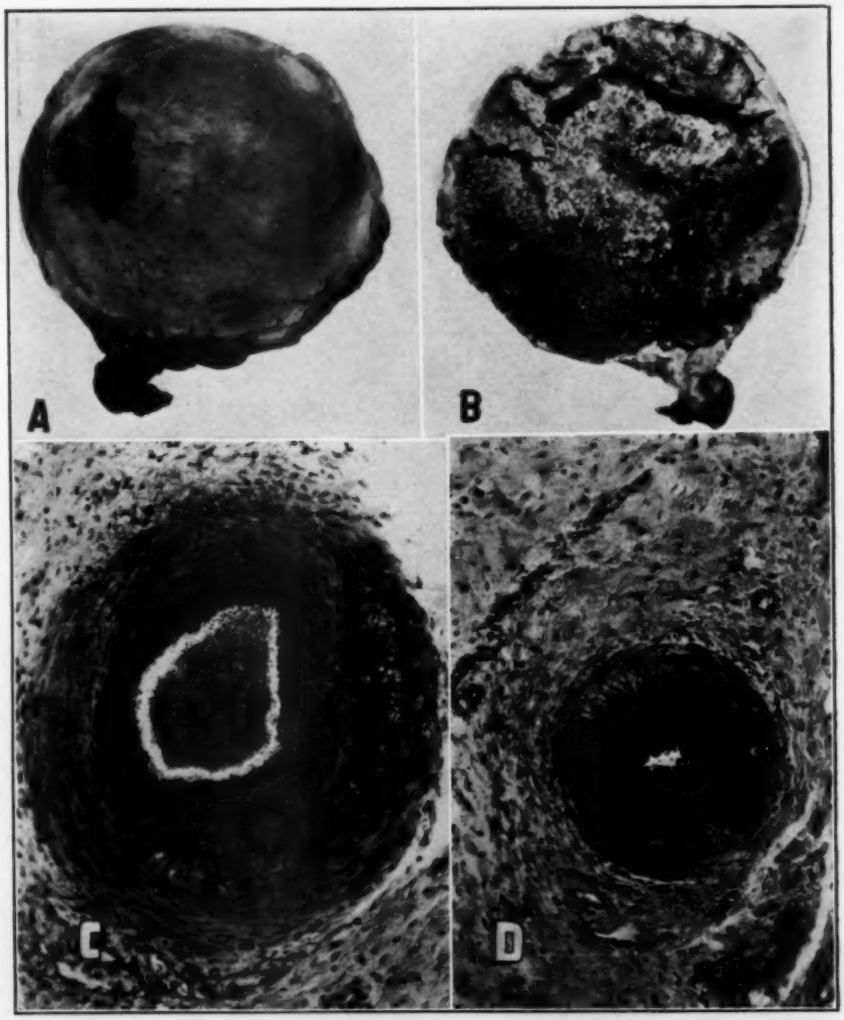

Fig. 5.—*A*, photograph illustrating the uneven articular surface of the amputated head of the femur (case 6). *B*, photograph of the surface made in amputating the head of the femur. Note the deep crevices and the sclerosed spongy bone (case 6). *C* and *D*, photomicrographs (× 105) illustrating the intimal fibrous tissue thickenings of the nutrient arteries in the ligamentum teres (case 6).

and the marrow spaces contained fibrous tissue. Tissue of special interest was taken from the margin of the bone. It contained masses of differentiated bone callus. Embedded in scar tissue was a large nutrient artery (fig. 4) with a thick wall and a compressed, narrow lumen.

CASE 6.—A white man aged 44 had pain in the left hip and knee intermittently for eleven months. He walked with a limp, favoring the left leg because of pain. There was no limitation in the motion of the left hip or knee. Extreme flexion or abduction of the left thigh caused pain in the hip joint and inner surface of the thigh. The Wassermann reaction of the blood serum was negative. Dr. E. L. Jenkinson noted in roentgen films taken Dec. 3, 1932, rarefaction of the head of the femur and depression of a portion of the upper and outer half. He considered these portions of the bone necrotic. On December 14 Dr. Fremont A. Chandler [10] exposed the left hip joint. He removed a dark red, swollen ligamentum teres, the head of the femur and a portion of the neck of the femur. Blood-stained fluids in the hip joint were sterile on culture. No further destruction of the proximal third of the femur was noted in a roentgenogram taken on July 12, 1933.

The amputated head of the left femur (figs. 5*A* and 5*B*) was hemispherical and measured 5.5 cm. in diameter. The surface made by the amputation was slightly concave; the thickness was about 2 cm. The fovea, 1 cm. from one edge, was 1.7 by 1.4 cm. The articular cartilage around this was elevated slightly, and about four fifths was pale gray-yellow and slightly granular. The cartilage was compressible. The surface made by amputation of the femoral head had a zone of condensed spongiosa along the periphery, 1.5 cm. wide. The sclerosed bone near the center contained yellow fat mottled with chalklike deposits 1 mm. in diameter. A crevice 1 to 3 mm. deep extended diagonally across the bone beneath the yellow, discolored articular cartilage.

The ligamentum teres, a pear-shaped mass of edematous fibrous tissue flattened on one side and rounded on the other, was 4 cm. long and 2.5 by 1.3 cm. at the broad end. The narrow end, measuring 0.7 by 0.4 cm., was attached to the fovea of the femur. A friable, necrotic region 1.5 by 0.8 by 0.8 cm. in the ligament was 1.8 cm. from the attachment of the femur. Some of the remaining edematous tissue was hemorrhagic.

A segment of bone 8 mm. thick, cut from the amputated head of the femur in a plane through the fovea capitis, was fixed in Zenker's solution, decalcified and embedded in pyroxylin, and the sections were stained with hematoxylin and eosin. A broad piece of articular cartilage with attached necrotic bone formed the roof of the large crevice, 2 to 7 mm. wide. Laterally, where the crevice reached the cartilage there was only a narrow bridge of cartilage or fibrous tissue. The bone trabeculae about this crevice were necrotic. The marrow spaces contained granular tissue débris and small fragments of necrotic bone (bone dust). Distal to the crevice this necrotic bone tissue extended variably to a depth of 8 mm. It merged into bone with marrow spaces containing edematous, poorly cellular fibrous tissue alone or with fat. There were small focal infiltrations of plasma cells and lymphocytes, but no reactive bone tissue was observed. The tissue of the ligamentum teres was edematous and hemorrhagic. Portions, as has been stated, were necrotic. A fibroblastic tissue reaction with chronic inflammatory exudates, recent hemorrhages and edema were the essential changes. There were many large and small arteries. These had thick muscular and fibrous walls and small lumens (figs. 5*C* and 5*D*).

CASE 7.—A white man aged 33 had pain and stiffness of both hips, especially the left, for three years. The pain was accentuated in the morning and when he walked. A waddling limp developed. This, associated with the pain, made walking difficult. The symptoms referable to the left hip were more marked than those

10. The clinical and pathologic disorders of the patients in cases 6 and 7 were reported by Dr. Chandler (Wisconsin M. J. **35**:585, 1936).

referable to the right. According to statements in the clinical record, this patient had carried heavy loads of meat on his shoulders. A diagnosis of aseptic necrosis of the head of each femur was made. Dr. Fremont A. Chandler reconstructed the left hip and removed the head of the femur on Dec. 26, 1934.

The cone-shaped head of the femur (fig. 6 *A* and 6 *B*), including a portion of the neck, was 6 by 5.5 cm. at the broken base and 5.5 cm. high. The articular surface was rough and extended to within 2.2 cm. of the broken surface at the base. This surface consisted of finely porous sclerosed bone. The irregular head was rounded abruptly at the tip. The fovea was an irregular depression 2 by 1.3 cm. and 0.9 cm. deep. A lip of bone tissue 8 mm. wide and 9 mm. long extended from the upper edge. A narrow, rounded, slightly overhanging lip on the opposite edge extended 12 mm. The articular surfaces were uneven, and portions were covered by fibrous tissue. A mass of cartilage 3 by 5.5 cm. with an uneven surface and loosened from the bone tissues was about 2 cm. below the prominent overhanging lip of the fovea. The hyperemic ligamentum teres was 5 cm. long and had been avulsed from the fovea of the femur with a piece of cartilage and fibrous tissue 1 by 1 by 0.2 cm. The ligament at the foveal attachment was 1.2 by 0.6 cm. and widened to 2 by 1.3 cm. at the acetabular end. The tissues were hemorrhagic. A "joint body" composed of two nodules held together closely was 1.5 by 0.8 by 0.3 cm.

The head of the femur was fixed in solution of formaldehyde, and two segments, each 7 mm. thick, were removed, one through the fovea and the other directly in front (fig. 6 *C*). They were decalcified and embedded in pyroxylin, and the sections were stained with hematoxylin and eosin. The overhanging lip (fig. 6 *D*) had a thin surface of articular cartilage and consisted mainly of bone trabeculae varying considerably in width. The small marrow spaces contained fat, alone or with fibrous tissue. Several pockets distributed in the peripheral portions of the head ranged to 1 cm. in diameter. They contained necrotic tissue débris and edematous fibrous or dense scar tissue. The bone trabeculae around these were not arranged regularly. Otherwise the structure of the bone varied mainly in density. Portions under the fovea and the displaced articular cartilage were compact; those near the neck approached the structure of the usual spongiosa. At some levels the large lip of the fovea had a second layer of cartilage beneath a thin plate of bone near the surface.

The ligamentum teres was sectioned at levels according to a sketch. It consisted mainly of fibrous tissue, dense near the center and less compact toward the periphery. There were a few recent hemorrhages. The blood vessels had thick muscular and fibrous walls. The lumens were small, and some of the large arterial branches showed fibrous tissue thickening (fig. 6 *E*) of the intima, which reduced the lumens to small slits or crevices.

Case 8.—A white woman aged 55 had pain in the right hip and knee for eighteen months. Eighteen months before the onset of the pain she had fallen and was said to have fractured the neck of the right femur. She was able to move about with crutches after seven weeks and without them after twelve weeks. The pain in the right hip was noted first in walking. It grew worse until she walked with a marked limp and needed the support of a cane. She entered St. Luke's Hospital with the diagnosis of aseptic necrosis of the head of the right femur and hypertrophic arthritis of the peripheral portion of the hip joint. Dr. E. W. Ryerson removed the head of the right femur (fig. 7 *A* and 7 *B*) on Oct. 25, 1934. The almost hemispherical piece of bone was 5.5 by 4.8 cm. across the broken surfaces. The maximum thickness eccentrically was 2.6 cm. The fovea, 2 by 1.5 cm., was in

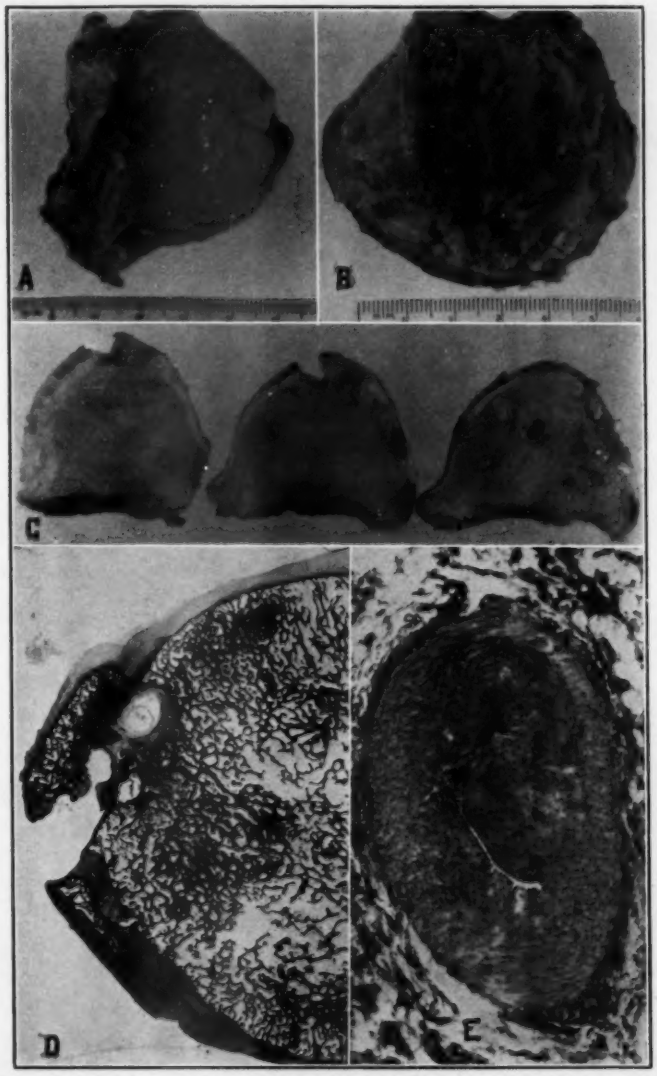

Fig. 6.—*A*, photograph illustrating the roughening of the articular surface of the head of the femur. Note the lip of bone tissue extending from the margin of the fovea (case 7). *B*, photograph of the bone surface made by amputating the head of the femur (case 7). *C*, surfaces made by sawing the head of the femur in front of the fovea, through the fovea and behind the fovea. Note the increased density of the spongiosa and the crevices filled with edematous fibrous tissue (case 7). *D*, photomicrograph of a section through the fovea, illustrating the changes in the bone structure (case 7). *E*, photomicrograph illustrating the fibrous tissue thickening of the intima and reduction in the lumen of nutrient arteries in the ligamentum teres (case 7).

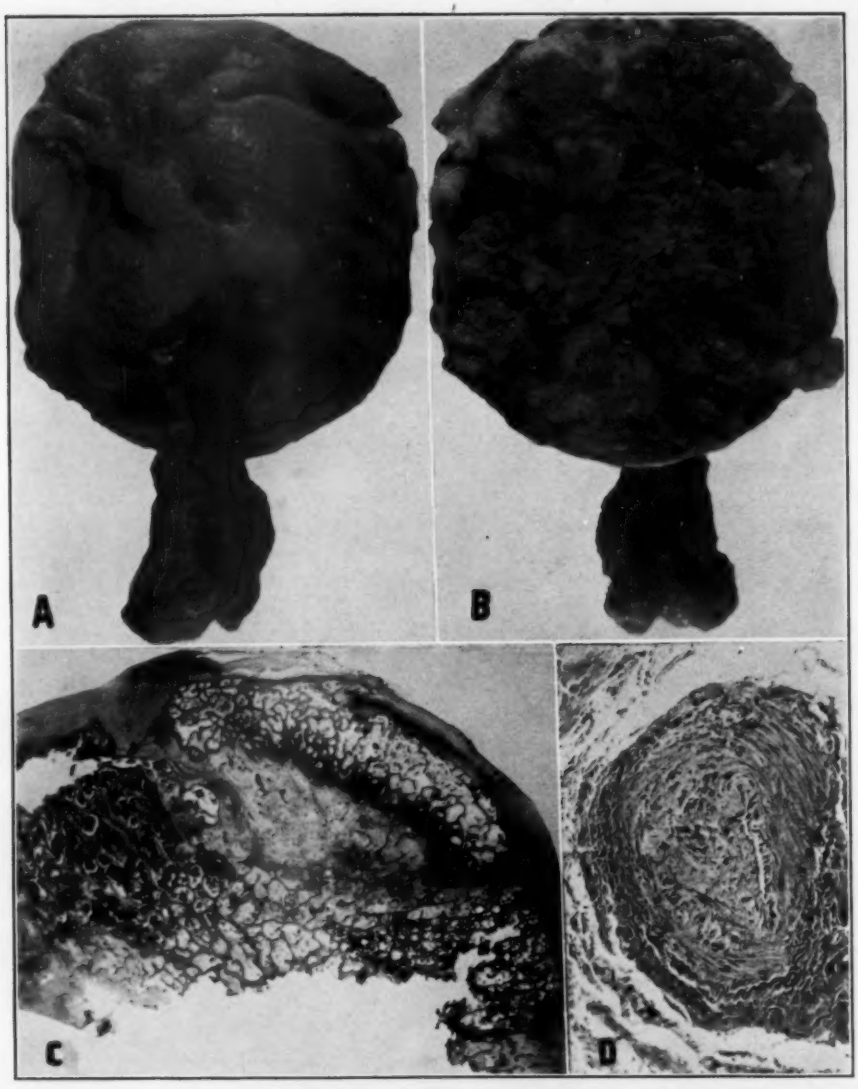

Fig. 7.—*A*, photograph of the amputated head of the femur with the attached ligamentum teres. Note the uneven articular surface (case 8). *B*, photograph of the surface made by amputating the head of the femur. Note the crevices and growths of fibrous tissues in the bone (case 8). *C*, photomicrograph of a section through the fovea. To the left in the illustration is a crevice. The articular cartilage has some attached necrotic bone. Beneath the crevice are other necrotic bone tissues and marrow spaces with "bone dust." On the right side of the illustration is a plate of restored bone, beneath which are other necrotic tissue (case 8). *D*, photomicrograph illustrating the fibrous tissue thickening of the intima and the reduced lumens of nutrient arteries in the ligamentum teres (case 8).

this portion of the articular surface. The ligamentum teres tissue attached to the fovea was 3.5 cm. long. At the fovea this edematous fibrous fat tissue was 8 mm. in diameter, at the other end 12 by 16 mm. The bone tissue in the surface made by amputating the femoral head was interrupted by several edematous bands of fibrous tissue 2 to 3 mm. wide, extending from the margins toward the center, more on one side than on the other. The bone tissue was sclerosed spongiosa. The surface of the articular cartilage was wrinkled. Several places were indented, and at least a half was loosely attached to the underlying bone. About a dozen irregular pieces of cortical and cancellous bone, some with wrinkled articular cartilage, formed a mass 5 by 4 by 3 cm.

Histologic preparations of a segment of bone 6 mm. thick cut from the center of the head through the fovea were prepared. The articular cartilage, with some bone, was detached from the margin to near the fovea, leaving a crevice (fig. 7 *C*). The spongiosa beneath the crevice to the surface made by amputation was necrotic. The marrow spaces contained granular tissue débris and small fragments of necrotic trabeculae (bone dust). Beneath the fovea and extending to the opposite edge was a layer of bone 5 mm. thick, to which the articular cartilage was adherent. Beneath this layer of bone was a zone of compact and edematous fibrous tissue 5 mm. wide. This decreased in amount on both sides in the planes examined and toward the neck of the femur extended into necrotic bone. Many of the marrow spaces between this layer and the plane of the amputation contained granular tissue débris. There was no bone callus tissue except around the plate of bone directly beneath the fovea. The deeper portions of this plate were dense like cortical bone. The tissue of the ligamentum teres was sectioned for histologic examination at four levels, according to a sketch. In these levels the central portions were dense fibrous tissue; the peripheral portions were edematous connective tissue. Many arterial branches (fig. 7 *D*) in this fibrous tissue had lumens reduced to small channels by concentric and eccentric fibrous tissue thickening of the intima.

CASE 9.—A white woman aged 33 had a constant ache or sharp pain in the left hip for twenty-one years. At the age of 15 years she had noticed a slight limp, which increased with her first pregnancy, at the age of 23. During childbirth and for two or three weeks thereafter the left hip was painful. With each of the succeeding three pregnancies the pain recurred, and after the last, at the age of 27 years, it became persistent. Six months before her admission to St. Luke's Hospital the pain became severe, and she walked with a noticeable limp. Dr. E. W. Ryerson on March 15, 1932, exposed the left hip joint and found a flattened femoral head with a thin piece of loosened articular cartilage and bone about 2.5 cm. in diameter on the superior surface. Bone tissue to a depth of about 2 cm. was removed. The diameter of the head was 6.5 cm. Near the center of the roughened articular surface was a rectangular piece of cartilage and bone 3.7 by 2.5 cm. by 6 mm. thick, hinged along one edge, raised slightly and loosely adherent to the bone tissues beneath. The surface made by the amputation was finely and coarsely porous sclerosed spongiosa. An irregular pocket near the center of this surface, 2.5 by 1 cm., contained loosely adherent, edematous connective tissue. The lining surfaces of the crevice were smooth sclerosed bone. The adjacent spongiosa also was dense. Tissues of the ligamentum teres were not submitted for histologic examination.

The hyaline articular cartilage was directly continuous with broad and narrow compact bone trabeculae. The large crevice in the bone extended at one place to near the articular cartilage. The lining of the crevice was a thin plate of compact

bone. The crevice was filled with edematous fibrillar connective tissue in which were a few medium-sized and small branches of nutrient arteries with narrow lumens. Concentric layers of coarse connective tissue fibers encircled these arteries (fig. 8 *A*), and outer portions of the walls of some of the larger showed fibrinoid degeneration. One of the latter was reduced to only a few smooth muscle cells

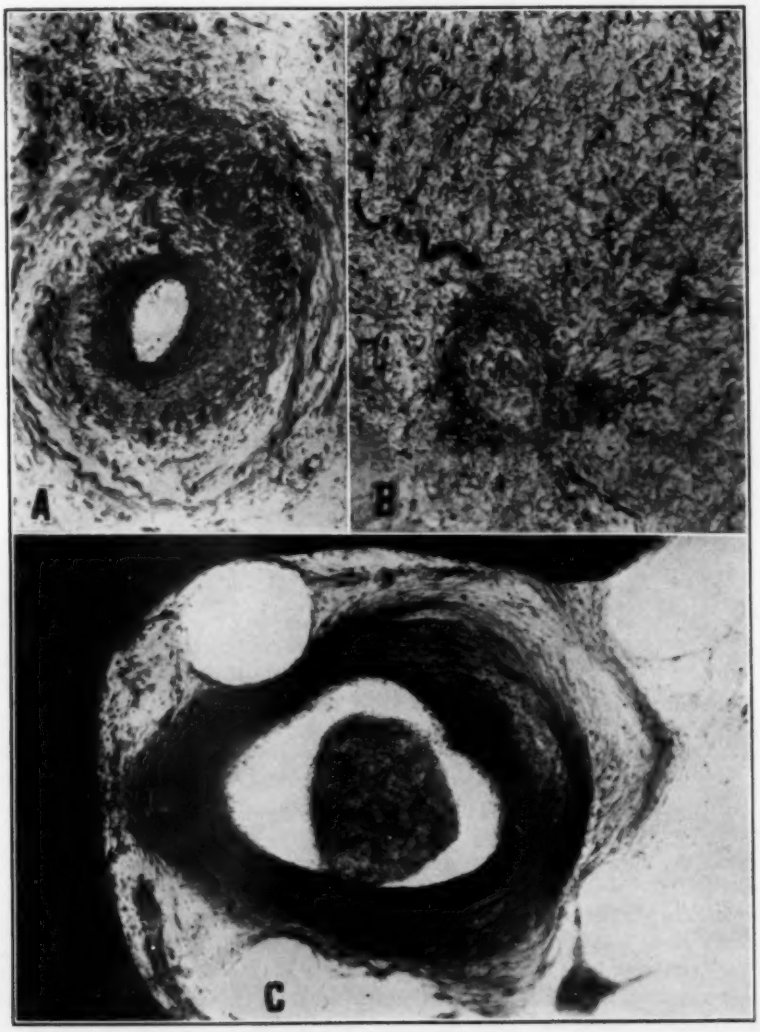

Fig. 8.—*A*, photomicrograph, × 105, illustrating the wall of a blood vessel in the edematous connective tissue of the bone crevice. Note the fibrous tissue thickening of the wall and the edema of the supporting stroma (case 9). *B*, photomicrograph, × 105, illustrating the edematous connective tissues in the bone crevice and the remaining structures of an arterial branch. Only a small capillary-like lumen remains (case 9). *C*, photomicrograph, × 105, illustrating a large branch of a nutrient artery in the femoral head. The wall is thickened by fibrous tissue, especially along the intima. The lumen contains a mass of erythrocytes and leukocytes (case 10).

embedded in fibrous tissue and having a capillary-like lumen (fig. 8 *B*). Small, narrow spaces immediately adjacent to the crevice contained mixtures of edematous fibrous and fatty tissues and small exudations of lymphocytes and plasma cells.

CASE 10.—A white man eged 64 was admitted to St. Luke's Hospital on Jan. 3, 1938, to the service of Dr. E. W. Ryerson, because of pain in the left hip for two years. About seven years before admission he fell from a ladder and fractured the proximal third of the neck of the left femur. The fracture seemed to have healed in about six months, with excellent restoration of function. The patient had pushed a cart on the streets until about four months before entering the hospital. Then the pain in the left hip had become marked, and he had a sensation of looseness in the joint. Roentgenograms disclosed flattening of the head of the femur and an increase of the angle caused by the old fracture of the femoral neck. Portions of the bone tissue were rarefied; other portions had increased density.

On January 6 Dr. E. W. Ryerson removed the head and portions of the neck of the left femur. The cone-shaped capital segment was 3.2 cm. thick, and the surface made by amputation was 6 by 5.5 cm. The fovea, lying eccentrically in the apex, was 2 by 1.5 cm. Edematous fibrous tissues of the ligament, 1.5 by 1.3 by 0.3 cm., were attached. The articular cartilage surfaces were uneven, and portions were loosened from the bone beneath. In some places the bone reached to the surface. The surface made by amputation contained broken cancellous bone tissue, some portions hyperemic, others yellow with fat. There were nine other pieces of bone, some from the head and others from the neck of the femur. The largest, with a convexly curved cartilage surface, was 5.5 by 2.5 by 2.5 cm. A crevice 2 by 1 cm. in the broken bone surface was filled with fibrous tissue.

A piece of bone 5 mm. wide was cut from the head of the femur in a plane through the fovea. Beneath the hyaline articular cartilage was a crevice filled with bone detritus and granular material. The bone tissues adherent to the cartilage had broad and narrow trabeculae. The marrow spaces near the cartilage contained fibrous tissue or fibrous and fatty tissue. Toward the crevice some of the fibrous tissue was necrotic. The edematous fibrous tissue attached to the fovea had nutrient arteries with muscular hypertrophy and fibrous thickenings of their walls. The lumens were narrow. The divisions of these vessels had small channels. A large nutrient artery deep in the bone (fig. 8 *C*) had a thick fibrous wall, and along the lining was a mural mass of red blood cells and fibrin.

COMMENT

Constriction and occlusion of nutrient arteries or of their intrinsic divisions by fibroblastic tissue have an important causal relation to aseptic necrosis of bone. In many of the cases herein described the constriction or occlusion was the result of trauma. Whether the narrowed channels and the fibrous tissue–thickened arterial walls are the loci of the injury or represent changes following an occlusion more proximal in the artery cannot be determined from the histologic preparations. Such vascular lesions, however, affect the nutrition of the bone tissues into which the vessels originally extended.

The extent of bone infarction caused by traumatic occlusion of the nutrient arteries or of their intrinsic branches is determined by the amount of vascular damage. The subsequent fate of the necrotic bone

depends on the vascular restitution which follows. When this is adequate and when reparative tissues develop sufficiently to withstand the stress applied to bone tissue, permanent restoration of function occurs. Should the restitution be inadequate, the disability becomes chronic. If restitution is only temporarily sufficient, an interval of restored function merges gradually into disability with roentgenographic evidence of aseptic necrosis. Such progressive manifestations result from the initial vascular injury or from compression of the intrinsic branches of nutrient arteries when bone structures weakened by vascular disturbances collapse under stress.

Large regions of aseptic necrosis (infarction) in bone are usually recognized without difficulty in the roentgenogram. Small infarcts of bone may develop into an insidious disability, difficult to diagnose clinically. In case 5 a slight trauma had injured an important nutrient artery of the femoral shaft. The results of the localized infarct and the subsequent tissue reactions produced shadows in the roentgenograms, which were interpreted in various ways. When dislocations of small bones, such as the bones of the wrist, injure the nutrient arteries, functional restoration is complicated. Simple reduction, then, does not correct the disablement caused by aseptic necrosis of bone.

The intrinsic branches of nutrient arteries of bones have muscular walls and a tissue structure similar to that of arterial branches elsewhere. The conditions of vascular repair and tissue restoration in bone with aseptic necrosis (infarction) differ from those for soft tissues. In bone, revascularization of necrotic portions occurs through the intrinsic blood vessels rather than from arterial branches of the surrounding soft tissues. The strength of the regenerated bone in the healing process must suffice to protect the intrinsic arterial branches against further injury by compression. The regions of bone tissue commonly involved in aseptic necrosis are so located that almost complete restitution of form and structure is necessary to prevent a disablement caused by a contraction deformity of the tissues. In this respect, the healing of an infarct of the bone contrasts with that of similar lesions of soft tissues, in which contraction and absorption in the healing are compensated.

If systemic chemical changes of bone are fundamental in aseptic necrosis, as argued by Block, and the vascular lesions incidental, the lesions of aseptic necrosis should be multiple. On the contrary, multiple lesions are unusual except in cases in which the same trauma injures the circulation in more than one bone, for example, in both femurs. The extensive aseptic necrosis of bone observed in caisson disease, recently described by Phemister,[11] is caused by interruption of the nutrition (circulation) in the affected portions of bones by gases liberated in the tissues.

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11. Phemister, D. B.: Proc. Inst. Med. Chicago **12**:82, 1938.

SUMMARY

Aseptic necrosis, a localized nutritional disturbance of bone, is regarded by some as an infarct of the tissues. The association of arterial occlusions or constrictions with regions of aseptic necrosis has been suggested but not clearly demonstrated.

Thickening of the walls of nutrient arteries and of their intrinsic branches by fibroplastic tissue, markedly reducing the lumens, was associated with aseptic necrosis in 9 large and small bones. In 1 small bone (of the wrist) an obturating thrombus filled the channel of an arterial branch at the margin of the necrotic portion.

Probably the greater number of such vascular constrictions or occlusions are due to trauma. Whether the lesions observed are at the actual site of injury or represent changes secondary to a constriction more proximal in the arterial system has not been established.

The conclusion is reasonable that vascular constrictions such as have been described cause definite nutritional disturbances (infarction) of the bone into which the vessels extend.

ADHERENT POSTERIOR DUODENAL ULCER

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In discussing the treatment of peptic ulcer, whether one is considering the medical or the surgical aspect of the problem one is confronted with the question of the treatment of duodenal ulcer, as approximately 85 per cent of all peptic ulcers are duodenal. Among 864 peptic ulcers which have come under observation during the past ten years in the gastroenterologic clinic of the fourth medical and surgical divisions of Bellevue Hospital, 88 per cent duodenal lesions have been encountered. The duodenal ulcer presents the chief problem both for the gastroenterologist and for the surgeon. It has been the policy in the clinic never to refer a patient for operation if any method of medical management would relieve the symptoms from which he was suffering. Therefore, during the past ten years only 10 per cent of the patients have been referred for operation. This point is important when one considers the pathologic process encountered in the late stages of duodenal ulcer and the type of operation essential to relieve the patient of his symptoms.

During the ten year period the 864 patients have made 16,776 visits to the clinic, an average of nineteen visits per patient. My impressions have been gained from personal observation of the patients in this clinic, as I have been in constant attendance during the entire period. Duodenal ulcer of fairly short duration (a year or less) offers a favorable prognosis if dietary management and general medical supervision are employed. From my observation it seems that 85 to 90 per cent of duodenal ulcers treated in the early stages can be cured or kept from producing symptoms with a medical regimen. When there is a history of symptoms of a number of years' duration the prognosis is definitely altered, bearing an inverse ratio to the number of years that the patient has been ill.

In this presentation I shall discuss the 10 per cent of duodenal ulcers for which operation was performed and the associated pathologic processes that were encountered. I shall also describe the treatment I consider necessary to restore the patient to health. When the gastroenterologic clinic was first organized (in January 1928) the chief objective was to determine whether any method of medical treatment would

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cure a duodenal ulcer. It was desired also to learn whether patients who could not be relieved by medical management could be permanently cured by any type of conservative gastric surgical operation. For the patients who were referred for operation during the first four years after the establishment of the clinic the operation performed was gastroenterostomy. After a few years enthusiasm for this procedure waned, as the patients on whom gastroenterostomy was performed had innumerable complaints. In 1933, Church and I [1] found that only 37 per cent of such patients were free from symptoms and that 16.4 per cent had marginal ulcers. In selected cases subtotal resection was done for duodenal lesions in 1932, and a posterior ulcer associated with an inflammatory process involving the head of the pancreas or the duodenohepatic ligament was a common finding. Since 1933 I have done subtotal resections exclusively for patients suffering from duodenal ulcer. It is this type of lesion that will be discussed at this time.

During the past four years and nine months, from Jan. 1, 1933, to Oct. 1, 1937, I have operated on 64 patients with duodenal ulcer. Thirty-two of the patients were referred from the clinic for persons with gastric disease of the Fourth Division at Bellevue Hospital, and 32 from my office.

It is essential to classify patients with duodenal ulcer into those on whom gastric operations have been previously performed and those on whom no such operation has been done. Of the 64 patients, previous gastric operations had been performed on 16, or 25 per cent. It is worth pointing out that these 16 patients had undergone twenty-four gastric operations before submitting to subtotal resection. Intractable pain furnished the reason for the radical operation, and 6 of the patients, in 10 instances, were operated on for multiple massive hemorrhages which were uncontrollable by medical management. The mortality in this group will be discussed later.

For the remaining 48 patients with duodenal ulcer primary subtotal resection was performed. This does not mean that laparotomy had never been performed on these patients; appendectomy or cholecystectomy had been performed on 13, or 27 per cent, and on several more than one exploratory laparotomy had been performed. For each of 3 patients three exploratory laparotomies had been done but had failed to disclose the cause of pain. It is the associated pathologic process encountered in the cases of these 48 patients that constitutes the chief interest in this presentation. Twenty-six, or 54 per cent, of these 48 patients had a posterior ulcer and definite chronic pancreatitis; in some

1. Church, R. E., and Hinton, J. W.: A Study of Six Hundred and Seventy-One Cases of Peptic Ulcer with Special Emphasis on One Hundred and Fourteen Postoperated Cases, New York State J. Med. **34**:1079 (Dec. 15) 1934.

cases the head of the pancreas was the size of a small orange, and in numerous instances it was the size of a lemon. Frequently the duodenohepatic ligament was also involved in the inflammatory mass. The associated pathologic process was unmistakable in every instance. Such single posterior ulcers do not represent the most extensive pathologic processes; it is with double duodenal lesions that the most marked pancreatitis is encountered, and each of 10, or 21 per cent, of the 48 patients had two ulcers in the duodenum. It is in such cases that one is liable to overlook the existence of pancreatic infection. The ulcer on the anterior surface of the duodenum gives one the impression that the lesion is only an anterior ulcer, but when patients with such a condition are operated on one is amazed at the extensive inflammatory involvement of the pancreas and the duodenohepatic ligament with a large posterior ulcer. The anterior ulcer usually proves to be relatively small. Deformity of the duodenum results from puckering caused by contracture of the scar tissue in and around the head of the pancreas.

This leaves among the 48 patients 12, or 25 per cent, who had an anterior ulcer which was penetrating or was adherent to the under surface of the liver or the gallbladder but no evidence of associated pancreatitis or involvement of the duodenohepatic ligament. If the patients with double ulcer are grouped with those with posterior ulcer it will be seen that 75 per cent of the patients in this series had a definite inflammatory process of the pancreas.

These patients were operated on for relief of either pain or hemorrhage; of the 48 patients, 39, or 81 per cent, were operated on for pain, and 9, or 19 per cent, were operated on for multiple massive hemorrhages that could not be controlled by medical management.

The clinical problem encountered for patients with chronic ulcer is to determine the stage at which the ulcer becomes adherent to an adjacent viscus. When this occurs the condition ceases to be amenable to medical management and requires immediate surgical intervention. Unfortunately there is no criterion for such a diagnosis except the history of pain and clinical judgment. The patient with a posterior ulcer and associated pancreatitis has a changed pain syndrome. The pain may be severe and may be referred to the back, either to the right or to the left of the spinal column. It may be so severe as to be confused with that caused by a renal calculus or by cholelithiasis. Of course, one always has the history of the previous symptoms of ulcer, and this is an invaluable aid in making a differential diagnosis. Unfortunately the gastrointestinal roentgenographic series is usually of little help in deciding whether a duodenal ulcer should be operated on. The findings may be indefinite, and if the lesion is a posterior ulcer the roentgenologist may be able to report only a duodenal deformity. Therefore, one should not be misled by the fact that the roentgenologist does not

give definite information. Pyloric obstruction may result from double duodenal ulcers of long standing, and occasionally it will result from a posterior ulcer. In only 15 per cent of my cases was there a definite organic obstruction of the pylorus.

Jones [2] in an article presented before the American Gastro-Enterological Association in 1936, on "The Surgical Aspect of Diseases of the Pancreas" stated: "I myself have never seen a case of chronic interstitial pancreatitis without hemorrhage or a fat necrosis diagnosticated before operation. Such conditions have no symptoms as far as I can determine." I am forced to take issue with this statement. I feel that if one sees duodenal ulcers in the late stages of the disease one will definitely be able to make a clinical diagnosis of the associated pancreatitis and refer the patient for operation. The 48 primary ulcers operated on in this series had an average duration of symptoms of thirteen and nine-tenths years before operation. This delay was important in producing chronic pancreatitis.

None of the laboratory tests that I have had occasion to use are of any practical significance. I have used the amylase test of Elman and his associates [3] on human beings and also on dogs in which the pancreatic ducts had been ligated, but I found that it gave no aid in diagnosing a chronic infection of the pancreas. The blood sugar curve is likewise of no value. Therefore, the diagnosis rests on the changed pain syndrome and the radiation of the pain to the back, with such severity that morphine or some other sedative is required to give relief.

For the past four years and nine months, as has been stated, for all duodenal ulcers on which I have operated the procedure has been subtotal resection. The operations included 16 secondary operations and 48 primary operations. In any discussion of resection for adherent posterior duodenal ulcer it should be made clear that for all the patients operated on the ulcer was completely removed from the pancreas or the duodenohepatic ligament. This point should be strongly emphasized, as I have had occasion to follow a few cases in which operation had been performed by other surgeons. The stomach had been resected and the inflammatory mass left in situ. The results were only fair. The pain suffered by the patient was apparently caused not by the ulcer but by the associated infection of the adjacent organ; therefore, one would hardly expect the patient to become free from symptoms if the ulcer is left in situ. The one argument used for not removing such a lesion

2. Jones, D. F.: Surgical Aspects of Diseases of the Pancreas, Am. J. Digest. Dis. & Nutrition **3**:686 (Nov.) 1936.

3. Elman, R.; Arneson, N., and Graham, E. A.: Value of Blood Amylase Estimations in the Diagnosis of Pancreatitic Disease, Arch. Surg. **19**:943 (Dec.) 1929.

is the difficulty of freeing the ulcer and the high mortality associated with resection. For that reason the mortality in this series will be presented. For the 48 primary subtotal resections there were 2 deaths, or a mortality of 4.1 per cent. For the 16 secondary gastric operations there were 5 deaths, or a mortality of 31 per cent. In the entire series of 64 cases there were 7 deaths, or a total mortality of 10.9 per cent. The mortality among the patients on whom secondary operations were performed certainly should not be counted as part of the mortality entailed by subtotal resection, as in such cases one is forced to undo what another surgeon has done. It is doubtful whether the mortality for conservative operations for the nation at large is as low as the mortality for subtotal resection in cases of duodenal ulcer; the reason for this is that pyloroplasty and gastroenterostomy are rather frequently done, whereas resection is performed by comparatively few surgeons.

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SACROCOCCYGEAL TERATOMA IN THE ADULT

REPORT OF A CASE

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Teratomas, while no longer looked on as a judgment from God, continue to intrigue and mystify the student of oncology. As a group, teratomas are among the rare forms of growth. In previous communications by Hundling,[1] Moersch[2] and Whittaker and Pemberton,[3] the rarity of sacral growths has been emphasized. These authors reported a total of 14 dermoids and 1 teratoma of the sacrococcygeal region. Whittaker and Pemberton concluded that ventral tumors of the sacrum occurred about once among 40,000 registrations at the Mayo Clinic and that only a small percentage of such tumors belonged to the group of congenital abnormalities. The rarity of teratoma of the sacrococcygeal region of adults, therefore, justifies this report. According to Harrington,[4] the sites of occurrence of teratoma, in order of frequency, are the pelvis, the abdomen, the sacrococcygeal region and the thorax. To these should be added the nervous system.

The exact origin of teratoma has not been fully established. Much progress has been made in the understanding of teratoma since Baillie's[5] report, in 1789, of an ovarian teratoma which occurred in a virgin girl aged 11. This was a severe blow to the prevalent idea that such tumors were the result of immoral practices. One must, however, content oneself with various hypotheses as to their origin. These have been clearly stated by Marshall,[6] who closely followed the work

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1. Hundling, H. W.: Ventral Tumors of the Sacrum, Surg., Gynec. & Obst. **38**:518-533 (April) 1924.

2. Moersch, F. P.: Sacral Tumors: Report of Forty-Two Cases with Special Reference to Their Neurologic Aspects, M. Clin. North America **10**:715-727 (Nov.) 1926.

3. Whittaker, L. D., and Pemberton, J. deJ.: Tumors Ventral to the Sacrum, Ann. Surg. **107**:96-106 (Jan.) 1938.

4. Harrington, S. W.: Surgical Treatment in Eleven Cases of Mediastinal and Intrathoracic Teratomas, J. Thoracic Surg. **3**:50-72 (Oct.) 1933.

5. Baillie, cited by Marshall.[6]

6. Marshall, G. G.: Dermoid Teeth in External Auditory Canal, with Comments on Teratomas and Dermoids in General, New England J. Med. **214**:202-204 (Jan. 30) 1936.

of Ewing.[7] They are: (1) defective closure of clefts with cellular inclusions; (2) misplaced blastomeres; (3) wandering of germ cells in the development of the embryo, and (4) parthenogenesis. Ewing classified these new growths as follows: monsters, teratomas, teratoid tumors, mixed tumors, dermoids and epidermoids. Briefly, it may be said that a teratoma is considered to be derived from all three germ layers, in contradistinction to a dermoid, which is derived from the ectodermal germ layer. Teratomas and dermoids are composed of both mature and embryonic cells. The latter cells tend to become malignant. Because of the uncertainty of differentiation of these various growths, Harrington has gone so far as to suggest that all such tumors be classified under the general heading of teratoma.

In a consideration of teratoma of the sacrococcygeal region, it has been well stated that the caudal end of the embryo represents a "Sargasso sea and the growths arising there produce a veritable potpourri of fetal tissues." The more important embryonal structures which give rise to sacrococcygeal growths are the coccygeal vestiges, the neurenteric canal, the postanal gut and the proctodeum. The more common abnormalities resulting from congenital embryonal disorders in the sacrococcygeal region are the teratoid tumors (teratomas and dermoids). The subject of chordoma, a tumor which is also of embryonal origin, has been fully reviewed by Fletcher, Woltman and Adson;[8] this tumor is not to be considered under the heading of teratoma. As a rule, teratoma of the sacrococcygeal region is not associated with neurologic changes, but at times defects of the spinal column and of the spinal cord and its membranes may occur. It should be stated in passing that teratoma of the spinal cord itself is rare, but cases which have been reported by Bucy and Buchanan,[9] Kubie and Fulton[10] and others indicate that any part of the spinal cord may be the site of a teratoma.

Teratoma of the sacral or sacrococcygeal region is probably present at birth and, acording to Ewing, may be on the dorsal or the anterior side of the sacrum or the coccyx. Hansmann and Berne[11] were of the opinion that such a growth always originates retrorectally and that it

7. Ewing, J.: Neoplastic Diseases, ed. 3, Philadelphia, W. B. Saunders Company, 1928, pp. 1016-1037.

8. Fletcher, E. M.; Woltman, H. W., and Adson, A. W.: Sacrococcygeal Chordomas: A Clinical and Pathologic Study, Arch. Neurol. & Psychiat. **33**: 283-299 (Feb.) 1935.

9. Bucy, P. C., and Buchanan, D. N.: Teratoma of the Spinal Cord, Surg., Gynec. & Obst. **60**:1137-1144 (June) 1935.

10. Kubie, L. S., and Fulton, J. F.: A Clinical and Pathological Study of Two Teratomatous Cysts of the Spinal Cord, Containing Mucus and Ciliated Cells, Surg., Gynec. & Obst. **47**:297-311 (Sept.) 1928.

11. Hansmann, G. H., and Berne, C. J.: Sacrococcygeal Teratomas, Arch. Surg. **25**:1090-1097 (Dec.) 1932.

gradually may force its way to the posterior part of the sacrum. Bucy and Haymond,[12] in a review of the literature on teratoma since 1800, said that teratoma of the dorsal part of the sacrum is rare in comparison with teratoma of the anterior part of the sacrum. A growth on the dorsal aspect of the sacrum may be associated with an anomaly of the neural canal, while one of the anterior portion of the sacrum is said to have no connection with the spinal cord or its membranes.

While sacrococcygeal teratoma is not common, it is of sufficient frequency to warrant consideration in the presence of a tumor of this region. Hansmann and Berne in 1932 reported a group of 26 cases of sacrococcygeal teratoma; 25 were collected from the literature between the years 1924 and 1929, and he added 1 case which he had observed personally. In these 26 cases, 19 of the patients were females and 6 were males; in 1 case the sex was not stated. Hosoi [13] in a review of cases of teratoma of the brain found that the incidence according to sex was reversed. In the majority of cases reported in the literature the teratoma occurred in a newborn or in a young infant. All of Hansmann's and Berne's 26 patients were less than 21 months of age. Love and Kernohan [14] have shown that in cases of dermoid tumor of the central nervous system the average age at the time of operation is 23 years. This is in contradistinction to the age incidence of teratoma. Kubie and Fulton reported a case of teratoma of the cervical segment of the spinal cord in which the patient was 27 years of age. As far as we have been able to determine from a review of the literature, there are relatively few reports of teratoma of the sacrococcygeal region of the adult. The reason for this is that the presence of the growth is discovered soon after birth. The patient is operated on and the growth removed, or the patient succumbs to the growth or to an unsuccessful operation before he reaches adult life. Nicholson [15] in 1937 reported a sarcococcygeal teratoma which contained three metatarsal bones and digits; the patient was a Chinese girl aged 16. Brines [16] in 1934 reported

12. Bucy, P. C., and Haymond, H. E.: Lumbosacral Teratoma Associated with Spina Bifida Occulta: Report of a Case with Review of the Literature, Am. J. Path. **8**:339-345 (May) 1932.

13. Hosoi, K.: Teratoma and Teratoid Tumors of the Brain. Arch. Path. **9**:1207-1219 (June) 1930; Intradural Teratoid Tumors of the Spinal Cord: Report of a Case, ibid. **11**:875-883 (June) 1931.

14. Love, J. G., and Kernohan, J. W.: Dermoid and Epidermoid Tumors (Cholesteatomas) of the Central Nervous System, J. A. M. A. **107**:1876-1882 (Dec. 5) 1936.

15. Nicholson, G. W.: Studies on Tumor Formation: A Sacrococcygeal Teratoma with Three Metacarpal Bones and Digits, Guy's Hosp. Rep. **87**:46-106 (Jan.) 1937.

16. Brines, R. J.: A Large Teratoma Containing Rudimentary Arm Bones and a Hand, J. A. M. A. **103**:338 (Aug. 4) 1934.

a case similar to ours, that is, a case in which a large teratoma contained rudimentary arm bones and a hand; the patient was a man aged 24. The tumor weighed 31 pounds (14.1 Kg.) and was attached to one side of the coccyx. It was removed successfully, and the patient's convalescence was uneventful. Aloi [17] reported a case in which a girl aged 19 had a teratoma of the lumbosacral region; the tumor was associated with spina bifida, but there was no involvement of the central nervous system. Bucy and Haymond and also Sonntag [18] have reported 2 similar cases, in which the patients were children. It may be doubted that such lumbosacral teratomas should be included under the general heading of sacrococcygeal teratoma. They are referred to here because no region of the spinal column appears to be exempt from such embryologic abnormalities.

Fig. 1.—Tumor of the right buttock.

REPORT OF CASE

A man aged 21 was admitted to the clinic in April 1936, because of a cystic tumor of the lower end of the spinal column, which had been present since birth. There was no history of disturbance of the function of the lower extremities or of the bowel or the bladder. The growth had gradually enlarged since birth and had kept pace with the general development of the patient. The tumor had never caused much trouble unless injured. At one time, after the patient had ridden on a farm machine over rough ground, the mass had become so tender and swollen that he had had to remain in bed for several days.

The family history revealed that the father had had a tumor on his back, but the nature of the tumor was unknown. The patient had five brothers and

17. Aloi, V., cited by Bucy and Haymond.[12]

18. Sonntag, F.: Angeborener Mischtumor der Lendenkreuzbeingegend nebst Spina bifida occulta, München. med. Wchnschr. **72**:516-517 (March 27) 1925.

Fig. 2.—Specimen removed at operation. At the top of the photograph, on the left, can be seen the cut end of the bone of the forearm which was attached to the coccyx.

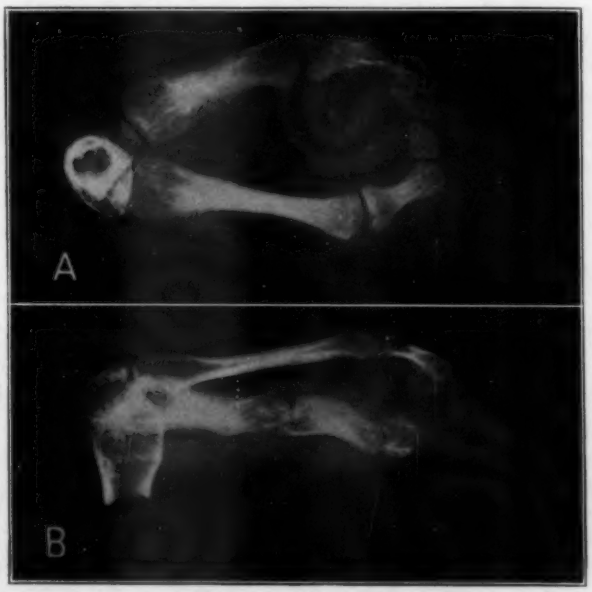

Fig. 3.—*A*, anteroposterior roentgenogram of the specimen, showing the bones of the hand. *B*, lateral roentgenogram of the specimen, showing the phalanges, the metacarpal bones, the carpal bones and the bone of the forearm which was resected from the coccyx.

three sisters, who were living and well when he came to the clinic. One brother had a harelip. There were no other developmental anomalies in the family.

Physical examination of the patient revealed no abnormality except a mass which was apparently attached to the end of the spinal column and extended out into the right buttock (fig. 1). The mass was not tender, and there were no signs of inflammation. On rectal examination the mass could be felt projecting toward the rectum on the right side. A careful neurologic investigation revealed no evidence of involvement of the central nervous system. The urine and the blood were normal. The flocculation test for syphilis gave a negative reaction. Roentgen examination of the sacrum disclosed a large cystic mass which was situated posterior to the lower part of the sacrum but apparently was not directly connected with it. Within the tumor mass one could distinguish well formed bony structures. The diagnosis was congenital tumor.

On April 14, 1936, the tumor (fig. 2) was removed by one of us (J. G. L.). The growth was situated at the lower end of the sacrum; it protruded into the right buttock, which was deformed, and extended across the midline, causing a deformity of the left buttock. The tumor was removed without any of the cysts being opened. It was attached by bone to the lower end of the coccyx on the right side. There was no connection with the meninges, and there was no suggestion of a meningocele. The tumor was intimately adherent to the rectum, and this structure had to be carefully dissected away from the tumor. This was done without injury to the bowel or to its blood supply. The tumor measured 10 by 5.5 by 33.5 cm. and weighed 117 Gm. When it was opened it was found to be cystic. It contained, in addition to the bones shown in the roentgenogram, hair and sebaceous material. The bones were well formed, and on the terminal phalanx of each finger was a long nail (fig. 3). The pathologic diagnosis, by Dr. J. W. Kernohan, was teratoma. The patient's convalescence was uneventful. When he was dismissed from the hospital, fourteen days after the operation, the results of neurologic examination were entirely negative, and his general condition was satisfactory. Recently (September 1937) a report from the patient's local surgeon stated that the patient had bruised his wound; this caused an abscess which had to be evacuated.

COMMENT

Sacrococcygeal tumors have been recognized for a long time, although their occurrence among adults is rare. A study of sacrococcygeal tumors reveals that they tend to be associated with the presence of rudimentary organs. Hosoi and others were inclined to agree that the origin of teratoma cannot be explained on the basis of a single embryologic maldevelopment as an invagination of the ectoderm at the time of closure of the primitive streak. On the contrary, this growth is derived from more than one germ layer and, as can usually be demonstrated, is trigeminal in origin.

The site of origin of sarcococcygeal teratoma is probably always retrorectal. The tumor may be attached to the rectum, to the sacrum or to the coccyx. Lumbosacral teratoma is closely related to sacrococcygeal teratoma but probably originates from a different embryonic focus. From a review of the literature it appears that the occurrence of teratoma has no relation to sex.

In the diagnosis of sacrococcygeal teratoma it must be recalled that if the tumor is situated anterior to the sacrum it may escape detection for many years. Consequently, in a case in which a sacral growth is suspected a careful rectal examination should be made in addition to the usual roentgenologic studies, as the latter may fail to reveal osseous changes. As reported by Fletcher, Woltman and Adson, chordoma is not infrequently present in the sacrococcygeal region and must be distinguished from teratoma. Other conditions to be considered in the differential diagnosis are tumor of the spinal cord, primary malignant tumor of the pelvis, metastatic growth, pelvic tumor (such as ovarian cyst), fibromyoma, adenoma, rectal fistula, pararectal abscess and finally spina bifida and meningocele.

De Veer and Browder [19] have laid down the following six points to aid in distinguishing meningocele from teratoma: 1. The skin covering a teratoma is usually normal, while the skin covering a meningocele or a myelomeningocele is of embryonal type. 2. A teratoma is usually larger and extends into the pelvis, while a meningocele is smaller and rarely extends anterior to the sacrum. 3. A teratoma tends to grow more rapidly than does a meningomyelocele. 4. A teratoma is solid and as a rule is not connected with the spinal canal, while a meningocele tends to be softer and does contain spinal fluid. 5. In cases of teratoma there are rarely any neurologic complications; in cases of meningocele or meningomyelocele neurologic complications frequently occur. 6. Hydrocephalus is a frequent accompaniment to a meningocele or a meningomyelocele, but it never is associated with a teratoma.

Teratoma of the spinal column is not confined to the sacrococcygeal region. It has been found in the cervical, thoracic and lumbosacral segments of the spinal cord and in the sacrococcygeal region.

As has been well demonstrated by the case which we have reported and by other cases reported in the literature, surgical removal of a sacrococcygeal teratoma is always worthy of consideration, and unless there is involvement of the spinal cord the results are exceedingly satisfactory.

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19. de Veer, J. A., and Browder, J.: Sacrococcygeal Teratoma, Ann. Surg. **105**:408-417 (March) 1937.

STERILIZATION OF THE AIR IN THE OPERATING ROOM BY BACTERICIDAL RADIANT ENERGY

RESULTS IN OVER EIGHT HUNDRED OPERATIONS

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DURHAM, N. C.

In previous publications [1] attention has been called to the prevalence of pathogenic bacteria, predominantly staphylococci, in the air in the operating room. Various precautions and procedures undertaken to eliminate these organisms from the air have been described. These preliminary measures were only partly effective, the most satisfactory being rigid isolation with reduction of the number of occupants to the minimum and forced ventilation with large quantities of air free of bacteria. The lowest bacterial contamination occurred during those periods when there were the fewest carriers among the operating room personnel and the general population. Since the number of carriers could not be controlled and since isolation and ventilation were only partly effective in freeing the air of bacteria, I turned to bactericidal radiant energy as a means of sterilizing the contaminated air in the region of the operative incision and the supply tables.[2] In continuation of work previously described [1] the bactericidal efficiency of these rays

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1. Hart, D.: Operation Room Infections: Control of Air-Borne Pathogenic Organisms, with Particular Reference to the Use of Special Bactericidal Radiant Energy; Preliminary Report, Arch. Surg. **34**:874-896 (May) 1937; Pathogenic Bacteria in the Air of Operating Rooms: Their Widespread Distribution and Methods of Control, Arch. Surg. **37**:521-530 (Oct.) 1938.

2. So-called sterile supply tables should never be left unprotected when this can be avoided. The table should be covered with a sterile sheet when it is not in use. While in use the table can be protected by general sterilization of the air, or, if there is objection to this, by an irradiation unit with a reflector which concentrates the rays on the table and prevents them from irradiating the entire room. With such a unit there is no necessity to cover all exposed cutaneous areas of the occupants of the room. However, any one who for a long time looks at the polished instruments, which might reflect a small amount of the radiation, should at least protect his eyes with glasses. If there is any tendency to cutaneous irritation from this small amount of reflected radiation it could probably be overcome by the application of cold cream to the skin before exposure.

has been reported [3] and a statistical analysis of small numbers of cases given.[4]

This report gives a brief analysis of the results obtained in a total of 456 clean primary incisions and 86 reopened clean incisions out of over 800 operations performed in a field of bactericidal radiation.[5] The other operations had a potential source of infection, and data on them were not used for the statistics. The operations in the present series were gastric or intestinal resections, cholecystectomies, appendectomies and amputations of gangrenous extremities. It is my impression that there has been a striking improvement in the postoperative course of these patients, but a statistical analysis was not made, since the results would

TABLE 1.—*Analysis of Clean Operative Incisions With Regard to Infections*

	Without Bactericidal Radiation			With Bactericidal Radiation		
	Total Cases	Infections		Total Cases	Infections	
Service	No.	No.	Percentage	No.	No.	Percentage
Urology	53	7	13.0	2	0	0
Orthopedics	144	5	3.5	65	0	0
Obstetrics and gynecology	245	7	3.0	1	0	0
General surgery	356	13	3.6	299	2*	0.7
Total	798	32	4.0	367	2*	0.5
Extrapleural thoracoplasties						
First stage	65	25	38.5	89	3†	3.4
Subsequent stages	45	11	24.5	86	7‡	8.1

* Cases 1 and 2.
† Cases 3, 4 and 6.
‡ Cases 5, 7, 8, 9, 10, 11 and 12.
In the past year and a half, most of the operations of magnitude have been performed in a field of bactericidal irradiation. This group, therefore, is composed largely of the operations of this type which are known from experience to be most likely to be followed by infection. The group in which radiation was not used, on the other hand, contains a higher percentage of operations of lesser magnitude in which infections are less likely to occur.

have been difficult to evaluate. In general, I may say that unexplained infections in primary incisions have been almost, if not entirely, eliminated (table 1).

More striking than this reduction in the number of infections (either gross suppuration or demonstration of organisms in the wound) has

3. Hart, D.: Sterilization of the Air in the Operating Room by Special Bactericidal Radiant Energy, J. Thoracic Surg. **6**:45-81 (Oct.) 1936.

4. Hart, D.: Sterilization of the Air in the Operating Room with Bactericidal Radiation: Comparative Analysis of One Hunderd and Thirty-Two Stages of Extrapleural Thoracoplasties Performed with Radiation and One Hundred and Ten Stages Performed Without Radiation, J. Thoracic Surg. **7**:525-535 (June) 1938.

5. This work has been made possible by the cooperation of the Westinghouse Electric and Manufacturing Company, which has supplied the radiation tubes and accessory electrical supplies. The statistical studies were made with the cooperation of Dr. Stokes Munroe and Dr. Phillip B. Parsons of the surgical staff.

been the reduction in the elevation of temperature following operation and the shortening of the duration of this postoperative elevation. Equally impressive has been the improvement in the postoperative course of the patients. They show less reaction in every way; there is less tenderness in the incision, and the period of convalescence is reduced.

In a consideration of the statistics, the summaries of all cases in which possible infection existed (cases 1 to 12 inclusive) should be carefully analyzed, note being taken of whether or not there is any doubt as to the presence of wound infection, the extent of the infection, the probable source of the contamination and the slight elevation of temperature in most cases.

In a number of cases, conditions classed as infections would have been overlooked except for careful observation and cultures of material from the wounds. Some of these conditions probably should not be classed as infections since the organisms were obtained only about the sutures which had been left in place for seven to nine days (cases 2 and 4) while in 1 case there was apparently inversion of the edge of the skin and organisms were cultured from the resultant granulating area (case 1). One should note whether the infection occurred in a primary incision or followed a second operation through a reopened incision. In the latter instance the organisms may have entered the subcutaneous tissues along the skin sutures of the preceding operation. In every primary incision showing any growth of organisms there was an evident source of the infection (cases 2, 3 and 6) or else there was doubt as to whether or not wound infection was present (cases 1 and 4). In all reopened wounds the skin sutures for the preceding operation formed a channel along which organisms could grow to gain access to the subcutaneous tissues. In 2 of the 7 reopened wounds which showed subsequent infection (cases 5, 7, 8, 9, 10, 11 and 12) there had been demonstrable infection about the skin sutures for the preceding stage of the operation (cases 4 and 6). In 1 the organism had been cultured from the skin sutures of the preceding stage but there was no evidence of wound infection (case 11). In another, in which there was no evidence of infection for the first two stages, a smear made during the third operation of material from the subcutaneous tissues at the level at which the skin sutures for the preceding stages had passed through showed an occasional coccus (case 12).

A statistical analysis of the 456 primary clean incisions, including the first stage of extrapleural thoracoplasties and 86 clean wounds that were reopened (extrapleural thoracoplasties for second and third stages), will be compared with the results obtained in similar groups of cases, in which the patients were operated on under the same conditions but

without the use of bactericidal radiant energy. The postoperative course of these two groups will be considered in the following order:

1. Number of infections (by services).
2. Infection and mortality statistics for extrapleural thoracoplasties, radical mastectomies and inguinal herniorrhaphies.
3. Postoperative elevation in temperature.
4. Duration of elevation in temperature following operation.
5. Wound healing and local reaction.
6. General systemic reaction.

For the group in which radiant energy was employed, a brief summary of each case classed as possibly presenting wound infection is given, together with the temperature curve for eight days after operation (cases 1 to 12, inclusive). It is not considered necessary or advisable to give abstracts and temperature curves for all the cases of infection in which bactericidal radiant energy was not used. The temperature, however, was much higher and the elevation was usually of longer duration than in the group for which irradiation was used. I recall (without a complete analysis of records) that over a period of several years, before the use of bactericidal radiation was begun, there were several deaths from infections with the hemolytic staphylococcus in supposedly clean operative wounds (3 craniotomies, 1 radical mastectomy, 4 extrapleural thoracoplasties[6]) and there were undoubtedly others. There has been no death from infection in cases in which the patients were operated on in a field of sterile air.

1. The number of infections has been greatly reduced (table 1). Considered by services, the orthopedic, the general surgical and the thoracic division are of greatest significance, since they have the largest number of cases. In the orthopedic service the infection percentage was reduced from 3.5 to 0. In the general surgical service while the reduction, as shown in table 1, was only from 3.6 to 0.7 per cent, a study of the summaries shows that in 1 case (case 1) it is extremely probable that the wound should not be classed as infected and that in the other (case 2) the only infection was an abscess about a single suture. Counting both of these cases as instances of infection, the percentage of infections in all cases, exclusive of cases in which thoracic operations were done, has been reduced from 4.0 to 0.5.

Thoracic operations are considered separately, since they are frequently multiple stage operations. In the series in which bactericidal radiant energy was not used, each operative procedure was carried out through a separate cutaneous incision because of fear of lighting up a dormant infection in the old incision. It is noteworthy that in this series in

6. Thoracoplasties performed without the use of bactericidal radiant energy are included in this statistical study.

which separate incisions were used there were 38.5 per cent infections[7] in the first stage and only 24.5 per cent in the subsequent stages (tables 1 and 2). In the series in which bactericidal radiant energy was employed the wounds were reopened for the second and third stages. The only infections in primary incisions (3 cases, or 3.4 per cent; see tables 1 and 2) are readily explainable as follows: The report of case 3 shows that there was gross contamination of the wound with infected perspiration as the result of tearing of a glove; the report of case 4 shows that in this case the upper end of the incision was exposed by slipping of the dressing; there was maceration caused by the patient's lying on the suture line; the skin sutures were left in for nine days, and a positive growth of Staphylococcus aureus was obtained from moisture along the suture line. The wound was described as well healed three days after the sutures were removed. The report of case 5 shows that the patient had acne with a pustular eruption over the back, and the incision was made with the cutting current with the idea of avoiding smearing organisms from the infected hair follicles and glands through the wound. Poor healing was the result. The dressing slipped, exposing the incision, and subsequently there was superficial infection in this area. After the operations in which a preexisting wound (usually of two to four weeks' duration) has been reopened, 8 per cent of patients have shown some infection (tables 1 and 2).

In all cases the infection has been localized, and in most of them it has been mild (cases 5, 7, 8, 9, 10, 11 and 12). It is my opinion that in most, if not all, of these cases the organism present in the hair follicles and sweat glands grew along the silk skin sutures for the preceding operation, thus reaching the subcutaneous tissues, where they lay relatively dormant until stirred up and spread by the subsequent operative procedure. Physicians are familiar with the fact that when the skin sutures are left in place for an unduly long time, these organisms may cause small abscesses about the sutures. There are many advantages in operating through the same incision, and since all but one of the infections have been mild I am still following this technic, in the hope that even such infections can be eliminated. Recently I have closed a number of extrapleural thoracoplasty wounds with deep sutures of catgut and a subcuticular suture of wire. In no case in which the wound was so closed has any infection followed reopening of the incision, regardless of whether the wound was reclosed with catgut and wire or with catgut and skin sutures of silk. The wire is removed at the following operation but can be removed at any time without an anesthetic by exposure through a few small nicks in the freshly healed scar.

2. Infection and mortality statistics for extrapleural thoracoplasties, radical mastectomies and inguinal herniorrhaphies are considered sepa-

7. This includes all cases in which there was either gross suppuration or a positive growth of organisms from smears made from the suture line.

rately, since cases in which these procedures are used form the relatively large series. This also allows a comparison of the results following operations of greater magnitude, such as thoracoplasties and mastectomies, with the results following the smaller operative procedures, as represented by inguinal herniorrhaphies (table 2). Infections following thoracoplasties have been considered. It should be noted that the reduction in the mortality from extrapleural thoracoplasties has been brought about by elimination of the mortality from wound infection in the series in which bactericidal radiant energy was employed (table 2). There has been no death in the other two series either with or without the use of this measure. For radical mastectomies the infections [8] have been cut from 31 to 2.6 per cent (a single stay suture abscess appearing on the eighth postoperative day in case 2) while for inguinal hernior-

TABLE 2.—*Infection and Mortality Statistics for Clean Operative Incisions*

	Without Bactericidal Radiation							With Bactericidal Radiation						
Type of Operation	Total Number of Cases	Wound Infection		Mortality from Wound Infection		Total Mortality		Total Number of Cases	Wound Infection		Mortality from Wound Infection		Total Mortality	
		No.	%	No.	%	No.	%		No.	%	No.	%	No.	%
Thoracoplasty														
First stage...	65	25	38.5	3	4.6	5	7.7	80	3*	3.4	0	0	2	2.2
Subsequent stages.....	45	11	24.5	1	2.2	1	2.2	86	7†	8.1	0	0	3	3.5
				3.6		5.5					0		2.9	
Radical mastectomy.....	13	4	31.0	0	0	0	0	38	1‡	2.6	0	0	0	0
Inguinal herniorrhaphy.....	150	5	3.3	0	0	0	0	87	1§	1.1	0	0	0	0

* Cases 3, 4 and 6.
† Cases 5, 7, 8, 9, 10, 11 and 12.
‡ Case 2.
§ Case 1.

rhaphies the infections have been cut from 3.3 per cent probably to 0, or to 1.1 per cent if a case in which it is very doubtful that the wound was infected (case 1) is included. In this case it is probable that the edge of the skin was inverted and that the organisms were cultured from the resulting small area of granulation tissue.

3. The reduction in postoperative elevation of temperature has been most striking. I feel that this, together with the shorter duration of elevated temperature, the diminished reaction in the wound and the less severe systemic reaction of the patient, are as important as, if not more important than, the reduction in the small percentage of diagnosed infections. All are indications of the reduction in the amount of bacterial contamination of the wound. The dividing line between the mild and the more pronounced elevations in temperature is taken as 38 C., or 100.4 F. For those who care to go into a more detailed

8. Gross suppuration or positive culture from the wound.

analysis, the smaller temperature divisions, with the number and percentage of cases in each, are given in tables 3, 4 and 5. By the use of bactericidal radiation to sterilize the air the percentage of patients

TABLE 3.—*Extrapleural Thoracoplasty for Pulmonary Tuberculosis; Temperature Elevation (Centigrade)*

Before Operation					After Operation				
Without Radiation		With Radiation		Temperature Groups	Without Radiation		With Radiation		
No.	Percentage	No.	Percentage		No.	Percentage	No.	Percentage	
97	88.2	152	87	37-36.5	2	2	37	21.0	
12	10.8	20	11	37-38.0	33	30 (32)	85	49.0 (70)	
1	1.0	3	2	37-39.0	58	52	46	26.0	
0	0	0	0	37-40.0	16	15 (68)	6	3.5 (30)	
0	0	0	0	37-41.0	1	1	1	0.5	
Total					110	100	175	100	

TABLE 4.—*Radical Mastectomy; Temperature Elevation (Centigrade)*

Before Operation					After Operation				
Without Radiation		With Radiation		Temperature Groups	Without Radiation		With Radiation		
No.	Percentage	No.	Percentage		No.	Percentage	No.	Percentage	
12	92.3	37	97	37-37.5	0	0 (54)	1	3 (66)	
1	7.7	1	3	37-38.0	7	53.8	24	63	
0	0	0	0	37-39.0	5	38.5	13	34	
0	0	0	0	37-40.0	1	7.7 (46)	0	0 (34)	
0	0	0	0	37-41.0	0	0	0	0	
Total					13	100	38	100	

TABLE 5.—*Inguinal Herniorrhaphy; Temperature Elevation (Centigrade)*

Before Operation					After Operation				
Without Radiation		With Radiation		Temperature Groups	Without Radiation		With Radiation		
No.	Percentage	No.	Percentage		No.	Percentage	No.	Percentage	
140	93.3	83	95.4	37-37.5	14	9.3 (64)	12	13.8 (78)	
8	5.3	4	4.6	37-38.0	82	54.7	56	64.4	
2	1.3	0	0	37-39.0	47	31.3	19	21.8	
0	0	0	0	37-40.0	7	4.7 (36)	0	0 (22)	
0	0	0	0	37-41.0	0	0	0	0	
Total					150	100	87	100	

having a temperature above 38 C. (100.4 F.) after operation was reduced as follows:

Thoracoplasties, from 68 to 30 per cent.
Radical mastectomies, from 46 to 34 per cent.
Inguinal herniorrhaphies, from 36 to 22 per cent.

4. With sterilization of the air in the operating room the shortening of the duration of elevated temperature following operation has been even more striking than the lowering of the temperature elevation (tables 6, 7 and 8). Taking four days as the dividing line between a relatively short and a more prolonged duration of elevated temperature, one finds that in cases in which bactericidal radiation was used the number of patients showing the longer course of fever has been reduced as follows:

Extrapleural thoracoplasties, from 78 to 22 per cent.
Radical mastectomies, from 54 to 21 per cent.
Inguinal herniorrhaphies, from 46 to 14 per cent.

For a more detailed analysis of the duration of high temperature the reader is referred to tables 6, 7 and 8.

5. By the use of bactericidal radiation, wound healing has been improved and the local reaction has been greatly diminished. The wounds usually remain dry, and there is little redness of the skin unless the patient lies on the incision (particularly in the summer, when there is much perspiration) or the sutures are left in place for an unduly long time (see report of case 4). The deep-seated reaction is diminished even when closure is made with catgut. The most striking difference noted is the diminution in the amount of soreness and pain in the incision. This is particularly evident in thoracoplasties.

6. The general systemic reaction of the patient after the operation is much less severe when the air is sterilized during the operation. This is most noticeable in major operations, such as thoracoplasties, mastectomies and arthroplasties. Taking the thoracoplasty as the best index, since there is a large series of cases and it is an operation of considerable magnitude, one finds that the patient seldom shows much systemic reaction other than the drop in blood pressure immediately following operation, and this is soon relieved by transfusion or other intravenous fluid. Convalescence is rapid, and in many cases the next operation is performed after an interval of fourteen days. The best index of the postoperative systemic reaction is probably the elevation of temperature (tables 3, 4 and 5) and the duration of this elevation (tables 6, 7 and 8). In my opinion, however, improvement in the systemic reaction has been even greater than the change in the extent and duration of elevation in temperature.

CASE 1.—G. B., a white boy aged 16, had an indirect inguinal hernia on the left side which had been present all his life. The hernia was repaired with the patient under nitrous oxide-oxygen anesthesia on November 26, silk being used as a suture material. When the skin sutures were removed on the sixth day the wound was described as well healed. On the twelfth postoperative day, when

TABLE 6.—*Extrapleural Thoracoplasty for Pulmonary Tuberculosis; Duration of Postoperative Temperature Elevation* *

Days	Without Radiation			With Radiation		
	No.	Percentage		No.	Percentage	
No postoperative elevation	2	2.0		42	24.0	
1	0	0		3	2.0	
2	1	1.0	22	39	22.0	78
3	11	10.0		22	13.0	
4	10	9.0		30	17.0	
5- 7	35	32.0		24	13.7	
8-14	39	35.0	78	9	5.0	22
15-21	6	5.5		3	1.7	
22+	6	5.5		3	1.7	
Total	110	100		175	100	

* Above 37.5 C. (99.5 F.), or the preoperative level.

TABLE 7.—*Radical Mastectomy; Duration of Postoperative Temperture Elevation* *

Days	Without Radiation			With Radiation		
	No.	Percentage		No.	Percentage	
No postoperative elevation	0	0		1	2.6	
1	0	0		0	0	
2	1	7.7	46	6	15.8	79
3	0	0		12	31.6	
4	5	38.5		11	29.0	
5- 7	5	38.5		6	15.8	
8-14	0	0	54	1	2.6	21
15-21	1	7.7		0	0	
22+	1	7.7		1	2.6	
Total	13	100		38	100	

* Above 37.5 C. (99.5 F.), or the preoperative level.

TABLE 8.—*Inguinal Herniorrhaphy; Duration of Postoperative Temperature Elevation* *

Days	Without Radiation			With Radiation		
	No.	Percentage		No.	Percentage	
No postoperative elevation	13	8.6		13	15.0	
1	0	0		2	2.3	
2	9	6.0	53.7	13	15.0	86
3	22	14.6		30	34.5	
4	37	24.5		17	19.5	
5- 7	55	37.0		9	10.3	
8-14	13	8.6	46.3	3	3.4	14
15-21	1	0.7		0	0	
22+	0	0		0	0	
Total	150	100		87	100	

* Above 37.5 C. (99.5 F.), or the preoperative level.

the dressing was again removed, there was some separation of the edges of the skin, with a raw area from which Staph. aureus was cultured. There was no evidence of infection below the surface. The patient was discharged the following day. The postoperative temperature curve is shown for the first eight days (chart 1). It remained normal throughout the remainder of the patient's stay in the hospital. This case probably should not be classed as one of infection.

Case 2.—M. H., a Negress aged 51, married, had a carcinoma of the breast, of sixteen months' duration. She had received eighteen roentgen treatments, and areas of skin had lost their pigmentation as a result of the blisters following these treatments. A radical mastectomy was performed on February 15. The postoperative temperature for the first eight days is given in chart 2. During the remainder of the stay in the hospital the temperature was normal. On the eighth day an abscess was found about a single stay suture which passed through the axillary hair-bearing skin. The remainder of the incision was free of any infection, and the abscess healed promptly, with little drainage, after removal of the offending stay suture.

Case 3.—D. C., a white woman aged 31, single, had a history of bilateral pulmonary tuberculosis of eight years' duration. Cavitation in the left lung had been present for the past four years. An extrapleural paravertebral thoracoplasty was performed on June 15. The operator's glove was torn during the operation, and gross inoculation of the wound with a considerable quantity of contaminated perspiration occurred. The wound was immediately and thoroughly washed out with physiologic solution of sodium chloride. A rapid rise of temperature followed operation, with evidence of wound infection (chart 3). The wound was opened six days after operation, for free drainage. Cultures showed Staph. aureus haemolyticus. Healing progressed satisfactorily and the remaining ribs were subsequently resected.

Case 4.—S. P., a white woman aged 32, single, had a history of tuberculosis of six years' duration and had had eleven ribs resected four years before admission. On October 1 an extrapleural paravertebral thoracoplasty was performed through the scar from the previous operation. The three upper regenerated ribs were resected. After the operation the temperature did not go above 38 C. (100.4 F.) and was down to normal within forty-eight hours (chart 4). After the operation the patient lay on her back during warm weather and perspired freely. The dressings slipped, the upper end of the incision being exposed. The silk skin sutures were not removed until the ninth day, at which time there was some superficial maceration at the upper end of the incision, with cutting of the silk sutures. Cultures taken from the suture line showed a growth of Staph. aureus. The incision was described as healed on the twelfth postoperative day, and there was no elevation of temperature before the next operation (see report of case 5). The infection in this case probably was not an operating room infection.

Case 5 (same patient as in case 4).—On October 15 a second stage extrapleural paravertebral thoracoplasty was performed through the incision for the first stage, with lengthening of the incision at the lower end. The regenerated fourth, fifth, sixth and seventh ribs were resected. After the operation the temperature did not go above 37.5 C. (99.5 F.) at any time (chart 5). The patient again lay on her back and perspired freely. The silk skin sutures were removed on the eighth day after the operation. There were numerous pustules about the sutures at this time. Cultures of pus from these showed Staph. aureus.

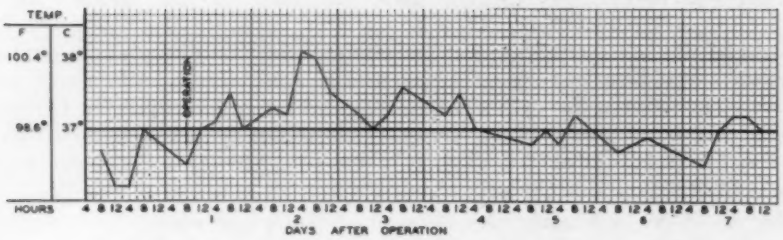

Chart 1.—Temperature chart of the patient in case 1.

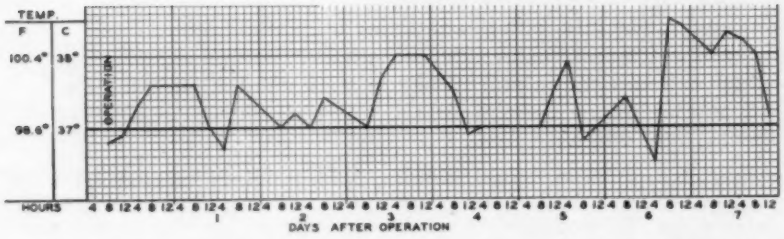

Chart 2.—Temperature chart of the patient in case 2. Radical mastectomy was the operation performed.

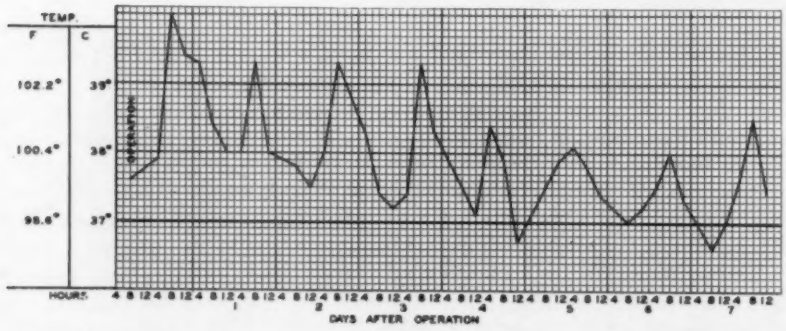

Chart 3.—Temeperature chart of the patient in case 3. An extrapleural paravertebral thoracoplasty was performed.

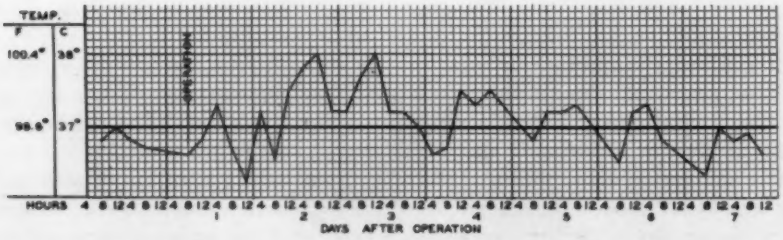

Chart 4.—Temperature chart of the patient in case 4. The first stage of an extrapleural paravertebral thoracoplasty was performed.

Practically all of these were healed two days later, but there was a small amount of drainage from the upper end of the incision. Photographs taken twelve days after operation showed the wound well healed, and the patient was discharged two and one-half weeks after the second operation. There was no elevation of temperature during the hospital stay after that shown on chart 5. The condition in this case probably was not an operating room infection but multiple stitch abscesses.

CASE 6.—S. G., a white man aged 23, single, showed, in addition to bilateral pulmonary tuberculosis of three years' duration with cavitation on the left, marked acne, with a pustular eruption over the back. Operation was delayed until the sixth day after admission in order that the cutaneous infection might be treated. On August 7 an extrapleural paravertebral thoracoplasty was performed on the left side, with resection of the first, second, third and fourth ribs. The incision was made with the surgical diathermy in the hope that it would be less likely to carry organisms into the wound. (I feel that this was false reasoning and that such a procedure probably gave the organisms more dead tissue in which to grow.) The cutaneous incision was closed with buried sutures of catgut and skin sutures of silk. The dressings slipped, and the upper end of the incision was exposed. Healing was delayed because of damage to the

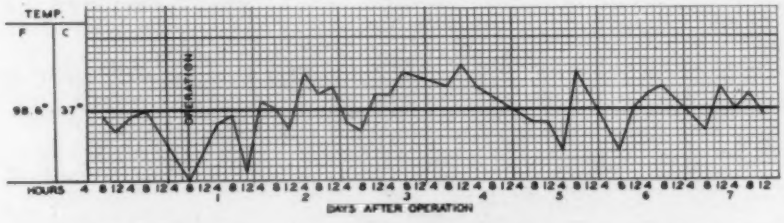

Chart 5.—Temperature chart of the patient in case 5 (the same patient as in case 4) after the second stage of the operation.

skin by the cutting current. A low grade superficial infection developed (chart 6). This healed before the second operation, thirty-five days after the first stage.

CASE 7 (same patient as in case 6).—The patient had a pustular eruption on the back, and there had been superficial infection at the first stage (chart 6). On September 10 the second stage of the thoracoplasty was performed through the scar from the first stage. The fifth, sixth, seventh and eighth ribs were resected. For twelve days after operation the temperature did not go above 38 C. (100.4 F.) except for the one point shown on chart 7. The sutures were removed on the ninth day, and the wound was described as well healed, with no infection. There was one recorded temperature daily above 38 C. (100.4 F.) on the fifteenth, sixteenth and seventeenth days after the second operation, and a hematoma was aspirated at this time. Dark brown, syrupy fluid was obtained. The culture was lost. Two small draining sinuses opened at the lower end of the incision by the twenty-fourth day after operation, but these drained only a slight amount of serosanguineous fluid.

The temperature remained irregularly elevated to above 38 C. (100.4 F.) daily. The wound was explored on the twenty-eighth day, but no pus was found, and there was little subsequent drainage from this incision, which was left open. The wound and sinuses healed by the twenty-ninth day after it was

opened, but the patient continued to have a temperature up to 38.5 C. (101.3 F.) several times each week. It was found that this came from secondary infection in an old tuberculous empyema cavity.

Case 8.—R. W., a white man aged 34, single, showed, in addition to tuberculosis of the right lung with cavitation, a blood pressure of 140 systolic and 92 diastolic and a diffuse pustular acneform eruption over the back, the shoulders and the upper parts of the arms. Operation was postponed, and the back was treated for sixteen days with measures producing cleanliness and with small doses of roentgen irradiation. Only moderate improvement was obtained.

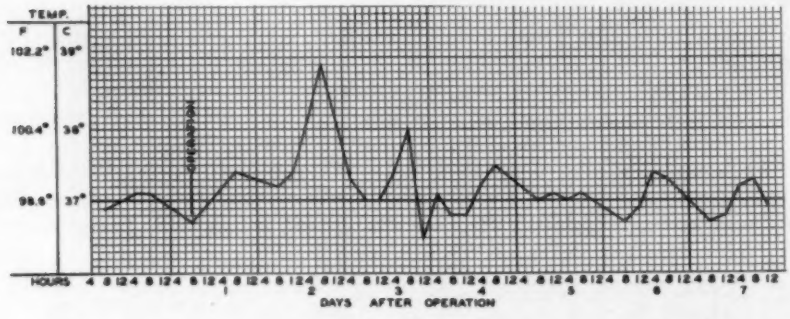

Chart 6.—Temperature chart of the patient in case 6. The first stage of an extrapleural paravertebral thoracoplasty was performed.

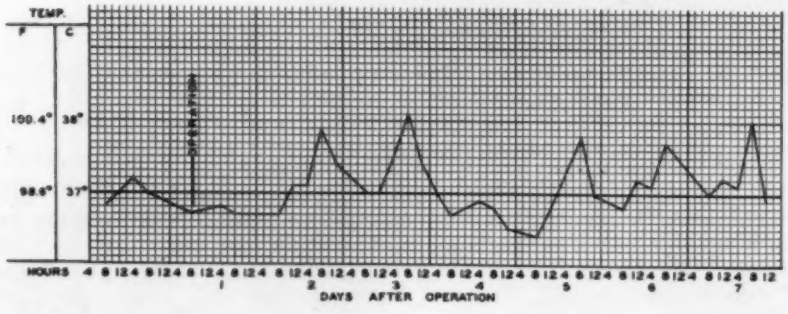

Chart 7.—Temperature chart of the patient in case 7 (same patient as in case 6) after the second stage of the operation.

On September 10 an extrapleural paravertebral thoracoplasty was performed on the right side, with resection of the first, second, third and fourth ribs. The maximum postoperative temperature was 38 C. (100.4 F.), and the temperature was normal after three days. There was primary healing.

On October 7 the second stage of the thoracoplasty was performed through the scar of the first operation, the fifth, sixth, seventh and eighth ribs being resected. The maximum temperature for the first eight days after operation, at the end of which time the sutures were removed (chart 8), was 38 C. (100.4 F.). The temperature gradually rose to 40 C. (104 F.) between the eighth

and the twelfth day, at which time the lower end of the incision was opened, a walled-off pocket of pus was evacuated and drains were inserted. The temperature dropped to normal within twelve hours and remained normal. Nine days after the abscess was drained, the patient had a sudden pain in the chest while straining in getting off a bedpan and died within a few minutes. Autopsy confirmed the diagnosis of pulmonary embolus. The wound had healed except for a small granulating area at the drainage site.

CASE 9.—M. G., a white woman aged 34, married, had a history of tuberculosis of the left lung of twenty-nine months' duration. Her general condition was good. There was a history of an acneform eruption during the menstrual periods.

The second stage extrapleural paravertebral thoracoplasty was performed fourteen days after the first stage, through the old incision. The fourth, fifth and sixth ribs were removed. Two hundred to 300 cc. of old blood was found beneath the scapula. The temperature had remained normal except for two days after the first operation. Immediately after the second stage it rose and remained elevated until a subcapsular abscess was drained (chart 9). This

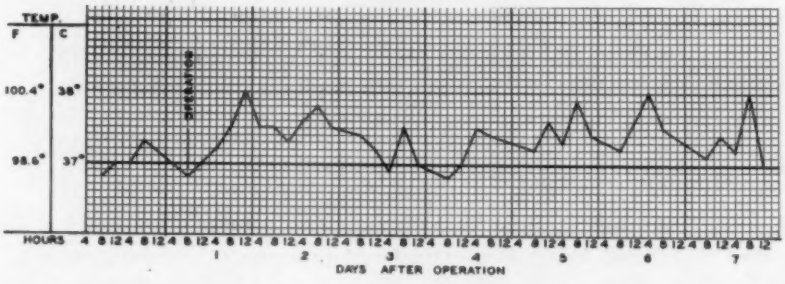

Chart 8.—Temperature chart of the patient in case 8 after reopening of the incision for the second stage of an extrapleural paravertebral thoracoplasty.

wound apparently became infected at the time of the second operation. The organisms may have gained entrance to the subcutaneous fat along the skin sutures for the first stage of the operation.

CASE 10.—J. W., a white man aged 23, single, had a history of tuberculosis of the left lung of three years' duration. The entire lung was fibrosed, and there was a cavity in the apex. The second stage extrapleural paravertebral thoracoplasty was performed twenty-one days after the first stage, through the original scar with removal of four ribs at each stage. (For the temperature curve following the second stage see chart 10.) A small collection of pus in the subcutaneous fat was discovered and drained on the sixth day after the operation. Culture showed Staph. aureus. The temperature curve subsequent to that shown in chart 10 was normal, but it required twenty days for the abscess cavity to granulate and the skin to heal over.

CASE 11.—R. C., a white woman aged 42, married, had a history of bilateral pulmonary tuberculosis of eighteen months' duration, with activity on the left. After the first stage, with removal of the first, second and third ribs, the temperature did not go above 37.8 C. (100 F.). While there was nothing to suggest infection, a culture of material from about the skin sutures showed a positive growth of Staphylococcus albus. The second stage was performed fifteen days

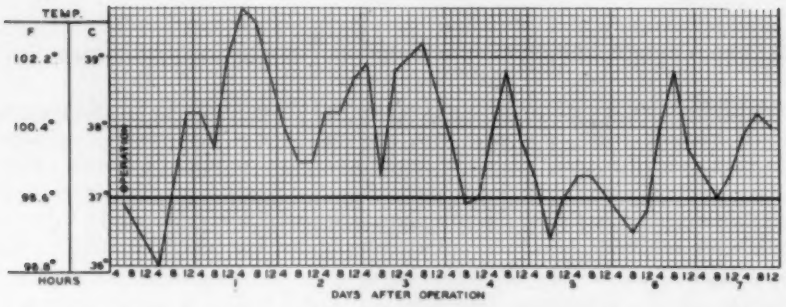

Chart 9.—Temperature chart of the patient in case 9 after reopening of the incision for the second stage of an extrapleural paravertebral thoracoplasty.

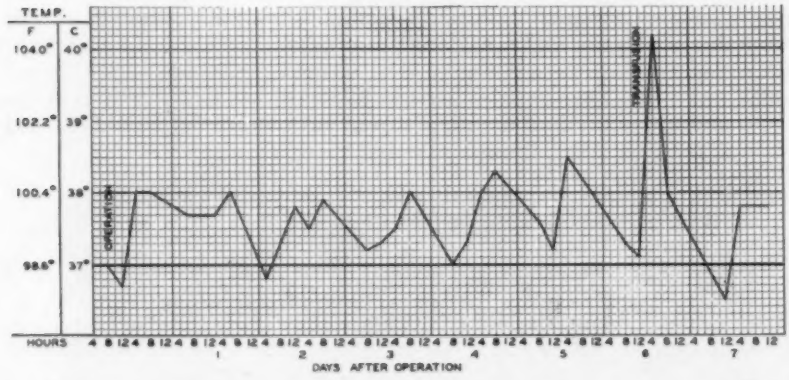

Chart 10.—Temperature chart of the patient in case 10 after reopening of the incision for the second stage of an extrapleural paravertebral thoracoplasty.

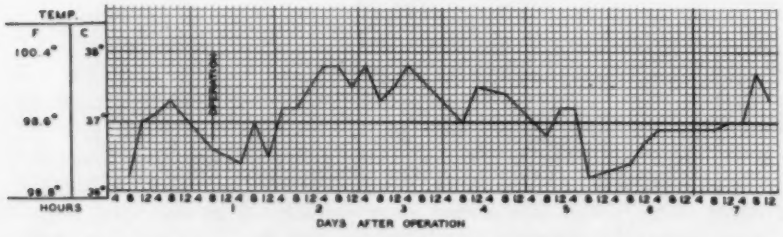

Chart 11.—Temperature chart of the patient in case 11 after reopening of the incision for the second stage of an extrapleural paravertebral thoracoplasty.

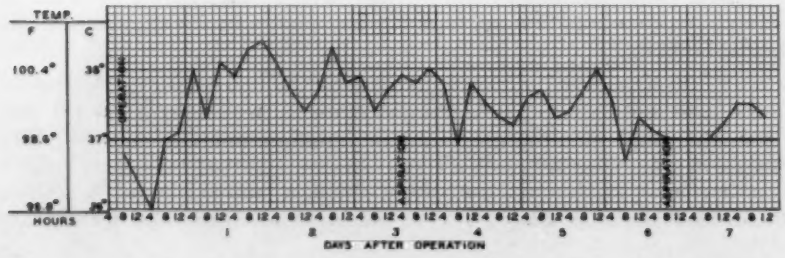

Chart 12.—Temperature chart of the patient in case 12 after the second reopening of the incision for the third stage of an extrapleural paravertebral thoracoplasty.

after the first. The incision was through the scar of the first stage, and parts of the fourth, fifth and sixth ribs were removed. The temperature (chart 11) did not go above 37.8 C. (100 F.). On the eighteenth day after operation a few drops of pus were expressed from the wound. The wound was opened, and pus (Staphylococcus albus and Staph. aureus) was found to be located about a buried silk suture. This was removed, and healing followed.

CASE 12.—P. M., a white woman aged 37, single, had a history of pulmonary tuberculosis of five years' duration. The disease was bilateral, well healed on the right but with several cavities on the left. The thoracoplasty was performed in three stages at fourteen day intervals. After the first and second stages the temperature remained between 37 and 38 C. (98.6 and 100.4 F.) and after each was normal four days after the operation. At the third operation smears of material from the superficial tissues at the level at which the skin sutures passed through the superficial fat showed an occasional coccus. After this operation the temperature went slightly higher (chart 12). A hematoma was aspirated on the third and seventh postoperative days. From material obtained by the second aspiration Staph. aureus haemolyticus was grown. A small opening was made for drainage and irrigation. Healing was satisfactory.

SUMMARY

This study of 456 clean primary incisions and 86 reopened incisions supposedly clean, out of a total of over 800 operations performed in a field of air sterilized by bactericidal radiation, demonstrates:

1. Reduction in the number of postoperative wound infections of over 85 per cent.

2. Elimination of the occasional death from wound infection.

3. Reduction in the number of patients with a postoperative temperature above 38 C. (100.4 F.) as follows:

Thoracoplasties, from 68 to 30 per cent.
Radical mastectomies, from 46 to 34 per cent.
Inguinal herniorrhaphies, from 36 to 22 per cent.

4. Reduction in the number of patients with a temperature elevation above 37.5 C. (99.5 F.) for more than four days after operation as follows:

Thoracoplasties, from 78 to 22 per cent.
Radical mastectomies, from 54 to 21 per cent.
Inguinal herniorrhaphies, from 46 to 14 per cent.

5. Improvement in wound healing.

6. Lessened systemic reaction.

7. Shortened convalescence.

CONCLUSIONS

The air in the operating room, as previously reported,[2] is highly contaminated with pathogenic bacteria.

This air is an important source of contamination in every operative wound.

Sterilization of the air in the operating room can be accomplished by means of bactericidal radiation, as previously reported.

With meticulous operating room asepsis, development of a delicate atraumatic technic, the use of the least irritating suture material, and the elimination of air-borne contamination of the operative wound and sterile supplies by the use of bactericidal radiant energy, wound infections in clean primary incisions may be almost eliminated.

Bacteria from the hair follicles and glands in the skin, breaks in technic or blood-borne bacteria from a focus elsewhere in the body are at present the only sources of infection of clean operative wounds.

END RESULTS IN CASES OF FIBROSARCOMA OF THE EXTREMITIES

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NEW YORK

Rules for the treatment of neoplastic disease must be based on carefully considered case reports in which complete data on the pathologic picture, clinical development, course, history and end results, to the death of the patient or at least to the end of a five year follow-up, are available to the reporter. The inclusion of cases in which the original diagnosis was made by an unknown pathologist is subject to the criticism that the pathologist may not have been expert in the diagnosis of tumor. The inclusion of cases dating to a previous decade is questionable unless the early slides can be reviewed, since the classification of many tumors has undergone extensive change in recent years. Reports of diagnoses made after biopsy of material taken by means of a punch or by aspiration, without subsequent study of additional tissue, are of questionable value. When the cause of death within a five year period is surmised or unknown the case should be excluded, since a patient with neoplastic disease may live for three years or more after operation and finally die from a cause unrelated to the tumor. The duration of tumor before operation must be known, since with the recent increase in "tumor consciousness" on the part of physicians and the laity the lesions are being seen in earlier stages than they were generally seen in the past. Prognosis may perhaps be comparatively more favorable for tumors of relatively recent occurrence.

These difficulties are particularly significant when an attempt is made to formulate rules for the treatment of fibrosarcoma of the extremities. Such a tumor, while not rare, is not sufficiently common to furnish a large series of complete cases to any one author. The classification of the sarcoma group has until recently been almost chaotic. Pathologic interpretation of sarcoma tissue requires extremely careful consideration since for the most part such tissue does not present characteristic cell formation as does that of certain other common neoplasms.

I have attempted to meet these requirements in a series of cases observed during the past five years. Complete data have been accumulated on 20 cases. Reports of 4 additional cases have been appended, for which five year end results or death have not been as yet recorded

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but which have been followed to a point at which the course was in complete accord with that of the cases in the first series. Before the cases are listed a clear definition of terms must be offered.

A fibroblastic tumor is a neoplasm of mesodermal origin, composed of cells whose ultimate function is the production of fibrous connective tissue. These tumors vary in structure within the limits of precursing tissue architecture and within the limits of adult connective tissue variations.[1]

In its malignant form such a tumor is designated by the term fibrosarcoma. Histologic variants, such as fibromyosarcoma, so-called angiofibrosarcoma and neurofibrosarcoma, present no differences in clinical development, subsequent course or response to treatment. (In order to avoid repetition the reader is referred to a previous paper for elucidation of these statements.[2])

REPORT OF CASES

CASE 1.—A woman aged 50 presented herself with a spindle cell fibrosarcoma on the foot, involving the subcutaneous fibrous tissue and tendon sheaths. The duration of the tumor was given as ten months. Attempts at aspiration had been made elsewhere on three occasions before her admission. The growth was increasing. A biopsy specimen was finally excised on March 9, 1933. Twenty-one days were spent in confirming the diagnosis. Amputation above the knee was performed on March 30. The lungs were not involved, as far as could be determined by roentgen study. The patient died May 25, about two months after the amputation. The lungs were apparently clear; at least, they were not grossly involved. There were metastases to the liver.

CASE 2.—A woman aged 21 came to the hospital with a fibrosarcoma originating in muscle or subsynovial connective tissue. The tumor was located chiefly within the gastrocnemius muscle, near the popliteal space. The primary tumor had been discovered in 1934, when it apparently had broken through to the subcutaneous tissue, presenting a visible mass. It was excised at that time. Subsequent observation showed that the primary excision was probably incomplete. The tumor recurred to clinically observable proportions within a few months. Secondary excision was attempted in June 1935. A third excision for secondary recurrence was found necessary in January 1936. This was followed by high voltage roentgen irradiation, 200 kilovolts at a distance of 50 cm., filtered with 0.5 mm. of copper. Treatment was given for fifty days; three fields were used around the knee and lower femur. Two thousand roentgens was given to the posterior field, 2,000 to the inner field and 2,250 to the popliteal space. The treatments were given practically daily in divided doses. Amputation was performed at the level of the upper part of the thigh on October 30. The patient died in April 1937. The lungs were roentgenologically normal before amputation but showed metastases before death.

CASE 3.—A man aged 50 presented a spindle cell fibrosarcoma on the anterior surface of the thigh, involving the fascial tissues. The duration of the tumor

1. Bick, E. M.: Fibroblastic Tumors of the Extremities, Arch. Surg. **35**:841 (Nov.) 1937.

2. Bick, E. M.: Fibrosarcoma of the Extremities, Ann. Surg. **101**:759, 1935.

was three years. It had been excised twice during this period before the present admission. Amputation was performed through the upper portion of the thigh in February 1934. Roentgen examination before the amputation showed no abnormality of the chest. The patient died from metastases in August.

CASE 4.—A man aged 48 presented himself with a spindle cell fibrosarcoma involving the fibula and the lateral surface of the leg. The tumor apparently originated from the periosteum. The duration of symptoms was three years. He had undergone primary excision before admission. Amputation at the level of the upper part of the thigh was performed in November 1936. The patient died early in 1937. Roentgenograms of the chest showed no abnormality before amputation. The primary tumor had not been recognized as involving bone; hence it had been incompletely excised.

CASE 5.—A man aged 42 presented a spindle cell fibrosarcoma originating in the subsynovial connective tissue at the level of the knee. A primary tumor had been excised two years before the present admission. The present admission was for a first recurrence. Amputation at the upper part of the thigh was performed in August 1928. The patient was living and well in September 1935.

CASE 6.—A woman aged 60 presented a spindle cell fibrosarcoma on the posterior aspect of the thigh, of fascial origin. The duration of the tumor was given as five months. The primary tumor was excised in September 1926; the first recurrent growth was excised in April 1927, and a second recurrent growth was declared inoperable in September. Roentgen examination showed metastases to the lungs in November. The patient died in March 1928.

CASE 7.—A woman aged about 30 presented a spindle cell fibrosarcoma, possibly of nerve sheath origin, from the region of the shoulder, involving the subcutaneous connective tissues. It was excised in November 1929; the operation was followed by a course of irradiation. The patient was living and well in January 1936.

CASE 8.—A woman aged 31 presented a fibrosarcoma of fascial origin in the thigh. The primary tumor appeared in 1924. It was excised and treated with irradiation, but it recurred. A second excision was performed in 1925, with further irradiation. The neoplasm again recurred; a third excision was performed in 1926; further irradiation was given. In October 1927, after a fourth recurrence, the growth was declared inoperable. Two weeks before the last recurrence a tumor was found in the abdomen. The patient died in November 1927, of general sarcomatosis.

CASE 9.—A man aged 75 presented a spindle cell fibrosarcoma involving the deep connective tissue of the heel. The primary tumor was found in 1926 and was excised. It recurred immediately and was again excised; a further recurrence (present admission) took place during December 1928. The tumor was again excised. The patient died in February 1930, of general sarcomatosis.

CASE 10.—A man aged 52 had a pleomorphous fibrosarcoma involving the fascial and deep fibrous tissues of the forearm. The tumor had been present two years before this admission. Primary excision was performed in 1932 and was followed by irradiation. However, the dose was never over 750 roentgens in divided doses. Histologically the tumor was classified as a fibromyxomatous type of fibrosarcoma at that time. It recurred and was excised in 1933; further irradiation therapy was employed. It again recurred during 1936 and was again excised. A third recurrent growth, which developed in May 1937, was also excised. The patient has lived five years. Each recurrent tumor has shown a more malignant type of tissue. Amputation has been advocated but declined.

CASE 14.—A girl aged 17 presented a vascular fibrosarcoma (so-called angiofibrosarcoma or angiosarcoma) located subcutaneously on the foot at the site of a benign nevus. It had first been observed only two weeks previously. It was excised by endotherm knife in 1926. The patient was living and well in December 1936.

CASE 12.—A woman aged 60 had a myxosarcoma involving the deep fascial tissues of the thigh, of six years' duration. It was excised in July 1928. There was no recurrence when the patient was examined in December 1932. She died of an unrelated cause in February 1934, at the age of 66.

CASE 13.—A man aged 22 presented a spindle cell fibrosarcoma of the thigh, involving the deep fascial tissues. The growth was of four years' duration. Excision had been attempted in November 1934 but was incomplete because of anatomic difficulties. Roentgenograms of the chest taken in October 1935 showed no abnormality. Amputation was refused by the patient. He died in 1936, of metastases to the lung.

CASE 14.—A man aged 24 had a spindle cell fibrosarcoma growing from the deep fibrous planes in the vicinity of the knee, of seven years' duration. The primary tumor was excised in February 1934 because of recent acceleration in growth. It recurred, and a secondary excision was performed in November, followed by irradiation. Eight portals of entry were used. One thousand roentgens was given to each of the eight fields, at 180 kilovolts, filtered with 0.5 mm. of copper and 1 mm. of aluminum. The treatment was given over forty-seven days. The distance was 50 cm. The patient died in December 1935, of mutiple metastases to the lungs, to the ribs and to the vertebrae.

CASE 15.—A man aged 35 had a fibrosarcoma of nerve sheath origin, attached to the sheath of the sciatic nerve. The duration of the tumor was given as four years. It was excised in September 1930. The patient was living and well in June 1935.

CASE 16.—A man aged 52 had a fibrosarcoma of the thigh, attached to the periosteum of the femur. Its duration was given as one month. It was excised in March 1933. The patient was living and well in November 1937, with no sign of recurrence.

CASE 17.—A woman aged 76 presented a polymorphocellular fibrosarcoma located in the fascial tissues of the thigh at the level of the upper third, of six months' duration. It was excised in December 1927. There was no recurrence. The patient died of bronchopneumonia in August 1931.

CASE 18.—A woman aged 52 presented a fibrosarcoma of the fascial tissues and subcutaneous connective tissues of the leg. The duration of the lesion was given as one year. It was excised in January 1924. Amputation at the level of the midthigh was performed one week later. The patient was living in May 1933 but had been admitted to another institution in January, because of cholecystitis. Roentgen study at that time revealed metastases to the lung. No final pathologic study of these metastases was made. However, the patient was alive and well nine years after the excision of the original tumor, without recurrence.

CASE 19.—A woman aged 41 had a fibrosarcoma involving the connective tissues overlying the deltoid muscle. The duration of the tumor was two years. It was excised in January 1934. The patient was living and well in November 1937.

CASE 20.—A woman aged 39 presented a spindle cell myxofibrosarcoma located in the fascial tissues of the thigh. It was excised in November 1933. The patient was living and well in November 1937.

ADDENDA

CASE 21.—A man aged 50 had a spindle cell fibrosarcoma involving the gastrocnemius muscle. Its duration was given as nine months. It was excised in October 1932, but it recurred. A second excision was effected in December 1933. The growth again recurred, and a third excision was performed in January 1934, followed by irradiation.

CASE 22.—A woman aged 35 had a spindle cell fibrosarcoma of the thigh, involving the deep connective tissues outside the muscle pack. It had first been noted three years previously. It was excised in May 1934. The patient was living and well in November 1937.

CASE 23.—A man aged 34 had a spindle cell fibrosarcoma on the anterior surface of the leg, probably of periosteal origin. It had been present for two years. Amputation was performed in June 1935. The patient was living and well in November 1937.

CASE 24.—A woman aged 31 presented a fibromyxosarcoma located on the leg, originating apparently from the interosseous fibrous tissue. Its duration was given as one and one-half years. It was excised in October 1928 and recurred with gradual acceleration. Amputation was performed in February 1936. The patient was living and well in November 1937.

ANALYSIS OF CASES

The clinical, developmental and pathologic characteristics of fibrosarcoma of the extremities have been presented elsewhere by me and therefore need not be repeated here. The following analysis will be concerned only with the results of treatment in the 20 cases listed in the main series.

Nine patients died as a result of neoplastic disease within a five year period. Eight patients (40 per cent) were alive without perceptible sign of recurrence or metastasis at the end of five years. One patient, a 76 year old woman, died of bronchopneumonia four years after primary excision, with no evidence of recurrence or metastasis of the tumor. Another patient died nine years after an amputation was done for neoplastic disease of questionable nature. A third patient is living at present, five years after the first excision, having suffered four recurrences treated by repeated wide excision and by irradiation. The later sections of tissue show an increasing degree of malignancy. In this case, while life has been extended to the time of writing, the disease has not been arrested.

On 8 of the 9 patients who died within a five year period, two or more excisions had been performed—that is, one or more excisions of locally recurrent tumor before amputation was performed or the tumor declared inoperable. In another case (case 13) excision was incomplete because of anatomic considerations, and amputation, although advised immediately afterward, was refused. In the second exceptional

case (case 4) excision was also incomplete since the tumor had invaded the adjacent fibula, which was not resected at the time. Later amputation did not save this patient. Hence, no patient lived after a recurrence of the tumor when a second excision was performed. High voltage roentgen therapy, used in 6 cases, did not alter the course of the disease. (In 3 cases the type of irradiation was listed. In the other, precise radiotherapeutic data were not available.) Furthermore, for none of the patients who died within the five year period was amputation performed before the appearance of local recurrence or at the time of local recurrence with the exception of the patients in cases 4 and 13, in which primary excision was incomplete.

Of the 8 patients alive without perceptible recurrence or metastasis at the end of five years, 5 were treated by complete surgical excision and 1 by incision with the endotherm knife. In none of these cases did local recurrence appear. Another patient was treated by complete surgical exicision of the primary tumor, followed by amputation for a recurrence two years later. Still another patient was treated by complete surgical excision followed by irradiation.

Of the 2 remaining patients, 1 (the patient in case 17) died of an unrelated cause four years after excision without evidence of recurrence or metastasis. Another (the patient in case 18) was a woman aged 52 whose thigh was amputated after a primary excision and who remained alive and well for nine years. She was then admitted to another institution, at the age of 61, because of gastrointestinal symptoms. A clinical diagnosis of cholecystitis was made. Roentgen studies revealed metastatic lesions in the chest. Autopsy was not performed. The origin or nature of the pulmonary metastasis was not determined. The lesions in this case cannot be ascribed to metastases from the amputated leg, occurring nine years later, although the possibility of its representing a single exception to the rule cannot be denied. This rule [1] is that the "expectancy of recurrence (in fibrosarcoma of the extremities) is highest in the first post-operative year and precipitately decreases after that."

In the 4 cases reported in the addenda, the tumor in case 21 recurred after three excisions followed by irradiation; the patient in case 22 is living and well at the time of writing, three and one-half years after primary surgical excision, and the patient in case 23 is living and well two and one-half years after primary amputation. In case 24 a tumor was excised and recurred with a slow rate of growth. The limb was amputated eight years later. The patient is alive and well almost two years later.

COMMENT

If histologic interpretation of the degree of malignancy of a given fibroblastic tumor were a matter of unquestionable accuracy, one could not avoid the conclusion that primary amputation is imperative in the treatment of fibrosarcoma of the extremities. Unfortunately, however, pathologic diagnosis "is not a factual statement; it is an interpretation of histologic appearance and must be so regarded. . . ."[1] Except for the general proposition that cellular tissues are more apt to be rapidly malignant than are relatively acellular tissues, I have not been able to establish any correlation between the histologic structure of a fibroblastic tumor and its relative malignancy. Hence, the appearance of some degree of cellularity or malignancy in a tissue reported as fibrosarcoma does not mean that the involved limb must be sacrificed to save life. There are listed in this report 7 of 20 cases in which no recurrence appeared within five years after local excision. Furthermore, no patient whose condition was not complicated died after a primary complete excision of a fibrosarcoma of the extremity before the appearance of a local recurrence. Two patients lived five years after amputation for a first local recurrence, and at the time of writing another patient has lived almost two years after amputation for a first recurrence.

Each case of fibroblastic tumor of an extremity presents an individual problem. Is the tumor benign? If it is borderline or obviously malignant, what is its virulence? Is it necessary to amputate? Is irradiation necessary? Can one afford to excise the tumor and continue observation for recurrence? The present work has been carried on for the past six years in the hope of answering these questions. On the basis of 20 complete and 4 partially complete cases carefully studied the following answers are submitted.

CONCLUSIONS

1. For any fibroblastic tumor of the extremity for which complete surgical excision of a primary lesion is anatomically feasible such treatment is indicated. By complete surgical removal is meant not only removal of the visible tumor tissue but removal of enough of the surrounding normal structure to make sure that there is no residue. The extent of the excision cannot be measured in centimeters; it must remain a matter of surgical judgment.

2. When complete surgical excision is not anatomically feasible, amputation of the limb is imperative at the time the primary tumor is judged malignant by competent study of the gross specimens in situ and by microscopic study of adequate tissue. This is true regardless of

the degree of malignancy as judged by the pathologist. It will be found that many fibrosarcomas of the deep fascial tissues of the thigh or fibrosarcomas originating in the periosteum of the femur fall within this category; that is, their complete surgical removal is difficult to assure.

3. Amputation is imperative at the first sign of recurrence of a fibrosarcoma.

4. Irradiation technic as applied up to this time has not been proved to alter the eventual outcome in such cases. Fibrosarcoma is resistant to present day radiotherapy.

SENSITIZATION AND DESENSITIZATION OF RABBITS TO HETEROPLASTIC TRANSPLANTS OF THYROID TISSUE

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OMAHA

In man isotransplants transferred directly without conditioning the donor, the recipient or the transplant seldom if ever survive permanently. Many such grafts take temporarily, for periods of three to five weeks, and then disintegrate and disappear. This phenomenon has been attributed to chemical incompatibility, and Holman [1] has presented evidence that it is based on the development of sensitization of the recipient to the foreign tissue. He reported the case of a child who received skin grafts from his mother on two occasions with a few days intervening. Both belonged to the same blood group. Two weeks after the second grafting, not only did the new epithelium which had spread from the grafts and had nearly covered the surface of the granulations melt away leaving only the original grafts, but symptoms of a generalized allergic reaction developed. These symptoms, fever, tachycardia, generalized exfoliative dermatitis or eczema and melena, persisted until the original grafts were removed from the surface with a curet. They then rapidly disappeared. Various attempts to develop a method of adapting the donor, the recipient or the grafts themselves have been made. Among methods investigated are preliminary transfusions of blood and injections of tissue extracts, and more recently tissue culture has been studied by Stone, Owings and Gey.[2]

With the exception of skin grafts, the transplants in these studies have been buried in muscle or other tissues where encapsulating and invading fibrous tissue has undoubtedly influenced the fate of the grafts. In the investigation reported below the transplants were cultured in the anterior chamber of the eye, and this location was selected because it has been observed in my similar previous studies [3] that much less fibrosis occurs in tissue cultured in the anterior chamber.

From the Departments of Surgery and Physiology, School of Medicine, University of Nebraska.

1. Holman, E.: Protein Sensitization in Iso-Skingrafting, Surg., Gynec. & Obst. **38**:100 (Jan.) 1924.

2. Stone, H. B.; Owings, J. C., and Gey, G. O.: Transplantation of Living Grafts of Thyroid and Parathyroid Glands, Ann. Surg. **100**:613 (Oct.) 1934.

3. Bisgard, J. D.: Ossification, Arch. Surg. **33**:926 (Dec.) 1936.

Thyroid and in a few instances ovarian and uterine tissues were used for transplants. These tissues were used for the reasons that they can be identified readily, that their states of cellular activity are reflected to some extent histologically and that some criteria of function of the transplants can be ascertained. Function can be determined in the case of thyroid transplants by the failure of evidence of thyroid deficiency to develop in totally thyroidectomized animals and in the case of utero-ovarian transplants by their reaction to estrogen from the urine of pregnant women injected intravenously. In contradistinction to those in man, heterotransplants in rabbits take readily and apparently function. However, as shown in the following experiments, these animals can be sensitized and desensitized to an individual transplant of tissue.

EXPERIMENTS

In 111 rabbits thyroid tissue was transplanted to the anterior chambers of both eyes. The technic has been described in a previous publication.[3] Immediately after removal, the tissue was cut into small bits with a sharp knife, the usual precautions being exercised to avoid trauma, drying and cooling. These fragments were gently threaded into the shaft of a large caliber needle, which was gently forced into the anterior chamber, entering it at the limbus. With the needle in place, the tissue was pushed from the shaft by means of a stilet and deposited in the anterior chamber. By this procedure, only avascular tissue is traumatized and there is no bleeding. Consequently, there is no interference with the "taking" of the graft by interposition of a hematoma. The transplants rapidly establish vascular communications with the iris.

All animals which received thyroid transplants were totally thyroidectomized either before or within a few days after transplantation. As stated previously, this was done to test the function of the grafts, which if functionally active would prevent signs and symptoms of hypothyroidism from developing. These signs are dry scaly skin, loss of most of the hair, some loss of weight, lethargy and hypochromic macrocytic anemia. Determinations of hemoglobin and erythrocyte counts were made on all animals before death except those which died spontaneously. These signs, it was found in a previous hematologic study [4] on totally thyroidectomized rabbits, developed in 75 per cent of the animals and appeared from eight to ten weeks after total thyroidectomy. The experiments fall into several groups, which will be outlined here and classified in the table. Several grafts were lost through infection of the eyes or inability to locate the grafts at autopsy or in sections, and some were discarded because the animals into which they had been placed died in less than twelve weeks after transplantation.

Group I: Autogenous Transplants.—Autogenous grafts of thyroid tissue were made to both eyes of 4 animals. Examined from fifty-two to one hundred and sixty-eight days later, 7 of the 8 grafts were found attached to the iris, and the tissue of each graft not only was viable but appeared to be hyperplastic. As evidence of hyperplasia the follicles were small and lined with tall cuboidal epithelium, and there was more than a normal quantity of lymphoid tissue. In a few areas thyroid tissue was missing and replaced by fibrous tissue. Since

4. Sharpe, J. C., and Bisgard, J. D.: The Relation of the Thyroid Gland to Hematopoiesis, J. Lab. & Clin. Med. **21**:347 (Jan.) 1936.

signs of myxedema did not develop in any animal in this group and since the transplanted tissue in each instance was hyperplastic, it would appear that the grafts functioned.

Group II: Isotransplants in Litter Mates.—In the second group transplantations were made directly to litter mates. Nine animals were used, and of the 18 transplants 12 survived, 3 were necrotic and 3 could not be found in the tissue removed at autopsy. The transplants were recovered for microscopic examination from forty-two to one hundred and sixty-six days after transplantation. In 2 animals no viable transplants were found, and in 1 of these signs of myxedema developed. With only 1 exception, the viable transplants found showed evidence not only of functional activity but also of hyperplasia. Photomicrographs of 1 of these transplants appear in figure 1.

In 4 rabbits segments of uterus and ovary from litter mates were transplanted to both eyes. At the same time these animals were totally oophorectomized. Six transplants survived and were histologically viable, as shown in photomicrographs in figure 2, and apparently were functioning one hundred and fifty-seven or one hundred and fifty-nine days after transplantation. In 1 animal both grafts had been replaced by connective tissue. On two occasions, sixty and one hundred and thirty-two days after transplantation, 15 cc. of urine from pregnant women was injected intravenously. Within thirty-six hours the eyes containing viable transplants became slightly injected and began to lacrimate. Some free blood appeared in the anterior chambers, and the transplants reacted as did those described by Allen and Priest.[5] The ovarian grafts enlarged to several times their original size, and their color changed from pale ivory to bright cherry red. Some tissue, presumably uterine, became pink. After forty-eight hours the reaction gradually regressed, and the ovarian transplants became salmon colored and finally ivory gray.

From these observations it would appear that heterotransplants in the rabbit not only survive transplantation in a large percentage of instances but also continue to function.

Group III: Isotransplants from Different Species of Rabbits.—Five albino rabbits received transplants from Belgian hares. Examined eighty-six to two hundred days later, 1 graft had been replaced by fibrous tissue and 5 were viable. Two of these showed hyperplasia. In 2 animals and in 1 eye of a third no thyroid tissue was found, probably as a result of inability to locate grafts in 3 eyes, loss from infection in 1 and loss from necrosis in 1. Myxedema developed in 1 rabbit. Thus 5, or 50 per cent of the total and 83 per cent of the 6 grafts recovered, survived and presumably functioned.

Group IV: Isotransplants of Thyroid Tissue of Dogs to Rabbits.—Four rabbits received transplants of thyroid tissue from dogs. At autopsy fifty-seven or one hundred and forty-four days later, no grafts could be found in 4 eyes. In the other 4 there was only necrotic and fibrous tissue. All eyes showed moderate inflammation for some time after transplantation. In all but 1 of these rabbits signs of myxedema developed. Thus there was both histologic and physiologic evidence that the grafts had failed to survive.

Group V: Isotransplants After Sensitization and Desensitization of the Recipient by Injections of the Donor's Blood.—A. Massive Injections of Blood

5. Allen, E., and Priest, F. O.: Physiological Response of Ectopic Ovarian and Endometrial Tissue, Surg., Gynec. & Obst. **55**:553 (Nov.) 1932.

Experiment	Rabbit No.	Injections of Blood: Pre-operative	Injections of Blood: Post-operative	Tissue Extract Pre-operative	Condition of Graft: Lost	Condition of Graft: Necrotic	Condition of Graft: Viable	Duration of Graft, Days	Hypothyroidism	Percentage of Takes
Group I	1	0	0	0	0	0	2H*	168	0	
Autogenous grafts	3	0	0	0	1	0	1H	112	0	
of thyroid	6	0	0	0	0	0	2H	115	0	
	19	0	0	0	0	0	2H	52	0	88
Group II	9	0	0	0	0	0	2H	42	0	
Isografts of litter	18	0	0	0	0	1	1H	136	0	
mates' thyroid	43	0	0	0	0	0	2H	119	0	
	45	0	0	0	1	1	0	139	+	
	55	0	0	0	1	1	0	141	0	
	90	0	0	0	1	0	1	166	0	
	121	0	0	0	0	0	2H	95	0	
	10	0	0	0	0	0	2H	130	0	
	5	0	0	0	0	0	2H	111	0	67
Group II	2	0	0	0	0	0	2	157	+†	
Isografts of litter	4	0	0	0	0	0	2	157	+†	
mates' uterus	82	0	0	0	0	0	2	150	+†	
and ovary	68	0	0	0	0	2	0	159	0	75
Group III	20	0	0	0	1	1	0	157	+	
Isografts of	21	0	0	0	2	0	0	157	0	
thyroid of a	34	0	0	0	0	0	2	155	0	
different species	35	0	0	0	1	0	1	200	0	
of rabbit	42	0	0	0	0	0	2H	86	0	50
Group IV	70	0	0	0	1	1	0	144	+	
Isografts of	71	0	0	0	2	0	0	144	+	
thyroid of a dog	72	0	0	0	0	2	0	57	0	
to a rabbit	73	0	0	0	1	1	0	144	+	0
Group V A	38	2	0	0	1	1	0	111	0	
Isografts of	78	2	0	0	0	2	0	118	+	
thyroid after the	11	1	0	0	0	2	0	125	+	
injection of 10 cc.	12	1	0	0	0	2	0	125	+	
of the donor's	13	3	0	0	0	2	0	112	0	
blood in a single dose	14	3	0	0	0	2	0	123	+	
	57	6	0	0	0	2	0	142	+	
	79	6	0	0	0	2	0	115	0	0
Group V B	02	7 daily	0	0	1	1	0	69	0	
Isografts of	E1	7 daily	0	0	1	1	0	150	+	
thyroid after daily	117	7 daily	0	0	1	1	0	108	0	
injections of 0.2 cc.	36	7 daily	0	0	0	2	0	115	+	0
of the donor's										
blood to recipient	39	14 daily	0	0	0	2	0	99	+	
	37	14 daily	0	0	0	2	0	146	+	
	40	14 daily	0	0	1	1	0	130	+	0
	41	28 daily	0	0	0	0	2H	88	0	
	46	28 daily	0	0	2	0	0	110	0	50
Group V C	74	25 daily	0	0	1	1	0	86	0	
Isografts of thyroid	76	25 daily	0	0	0	2	0	55	0	0
of a dog to a rabbit										
after daily injections										
of 0.2 cc. of the										
donor's blood to										
the recipient										
Group V D	64	0	5	0	0	2	0	136	+	
Isografts followed	80	0	5	0	2	0	0	120	0	
by the injection of	83	0	5	0	0	0	2H	248	0	
10 cc. of the donor's	65	0	21	0	0	2	0	136	0	
blood to the recipient	67	0	42	0	0	2	0	118	+	
in a single dose	86	0	42	0	0	2	0	166	+	
postoperatively	87	0	42	0	0	0	2H	215	0	29
Group VI	88	7 daily	0	0	0	1	1	121	+	
Isografts of thyroid	103	7 daily	0	0	0	2	0	120	+	
after daily injections	60	14 daily	0	0	0	2	0	121	+	
of 0.2 cc. of the	62	14 daily	0	0	0	2	0	117	+	
recipient's blood	51	14 daily	0	0	1	1	0	52	0	10
to the donor										
	49	28 daily	0	0	1	1	0	70	0	
	53	28 daily	0	0	1	0	1H	121	0	25

* H signifies hyperplastic condition.
† Positive Aschheim-Zondek tests were made on the rabbits thus marked.

Results of Experiments—Continued

Experiment	Rabbit No.	Injections of Blood: Pre-operative	Injections of Blood: Post-operative	Tissue Extract Pre-operative	Condition of Graft: Lost	Condition of Graft: Necrotic	Condition of Graft: Viable	Duration of Graft, Days	Hypothyroidism	Percentage of Takes
Group VII	28	7 daily	0	0	0	2	0	149	+	
Isografts of	23	7 daily	0	0	0	2	0	64	0	
thyroid after	29	7 daily	0	0	1	1	0	149	+	0
reciprocal daily injection of 0.2 cc.	24	14 daily	0	0	0	2	0	108	0	
of blood	25	14 daily	0	0	0	2	0	143	+	
	31	14 daily	0	0	0	2	0	94	0	0
	26	28 daily	0	0	1	1	0	128	0	
	32	28 daily	0	0	0	2	0	128	+	
	27	28 daily	0	0	0	2	0	128	+	
	33	28 daily	0	0	1	0	1H	159	0	12.5
Group VIII	118	7 daily	0	0	0	2	0	130	0	
Isografts of thyroid	119	7 daily	0	0	0	0	2	130	0	
(1) after preliminary	02	7 daily	0	0	1	0	1	69	0	
daily injections of	112	14 daily	0	0	0	0	2	130	0	
0.2 cc. of nonspecific blood	113	14 daily	0	0	1	1	0	126	0	
(2) followed by	114	0	7 (single inj.)	0	0	0	2H	93	0	
10 cc. of nonspecific blood in a single dose	115	0	7 (single inj.)	0	0	1	1	95	0	57
Group IX A	94	0	0	0	0	2	0	120	0	
The injection of	97	0	0	0	0	2	0	21	0	
isografts of human	98	0	0	0	1	1	0	37	0	
thyroid to a rabbit	99	0	0	0	1	1	0	28	0	
	100	0	0	0	0	2	0	42	0	
Group IX B	95	28 daily	0	0	0	2	0	31	0	
Isografts of human	96	28 daily	0	0	0	2	0	61	0	
thyroid to a rabbit	109	28 daily	0	0	1	1	0	21	0	
after daily injections of 0.2 cc. of blood	110	28 daily	0	0	0	2	0	26	0	0
Group X	3B	0	0	7 daily	0	1	1H	101	0	
Isografts of	4B	0	0	7 daily	1	1	0	99	+	
thyroid after	5B	0	0	7 daily	2	0	0	85	0	17
daily injections of extract of the	6B	0	0	14 daily	0	2	0	120	+	
donor's thyroid	7B	0	0	14 daily	1	1	0	110	0	
	12B	0	0	14 daily	0	0	2H	110	0	
	15B	0	0	14 daily	0	2	0	94	+	
	16B	0	0	14 daily	0	2	0	110	0	
	17B	0	0	14 daily	0	2	0	80	0	
	18B	0	0	14 daily	1	1	0	90	+	
	20B	0	0	14 daily	1	0	1H	92	0	19
	27B	0	0	22 daily	0	0	2H	110	0	
	29B	0	0	22 daily	0	2	0	100	0	
	30B	0	0	22 daily	0	1	1	110	0	
	34B	0	0	22 daily	0	0	2H	110	0	63

from the Donor of the Tissue Before Transplantation: Eight rabbits were given 10 cc. of blood in one injection (some intravenously) and one, two, three and six days later received transplants of thyroid tissue from the animals from which they had received blood. When they were examined, from one hundred and eleven to one hundred and forty-two days subsequently, no viable transplanted tissue was found. In 15 instances it appeared that the grafts had become necrotic and been replaced by fibrous tissue. In 5 of the 8 animals myxedema developed.

B. Repeated Small Injections of the Donor's Blood: Nine rabbits were given daily injections of 0.4 cc. of laked blood (composed of equal parts of water and blood) intramuscularly for periods as listed and then received thyroid transplants from their respective donors of blood. Autopsies were performed on the animals from sixty-nine to one hundred and fifty days later.

1. Four received daily injections for one week; no viable thyroid tissue was found, and 5 grafts had been replaced by fibrous tissue. In 2 of the rabbits myxedema developed.

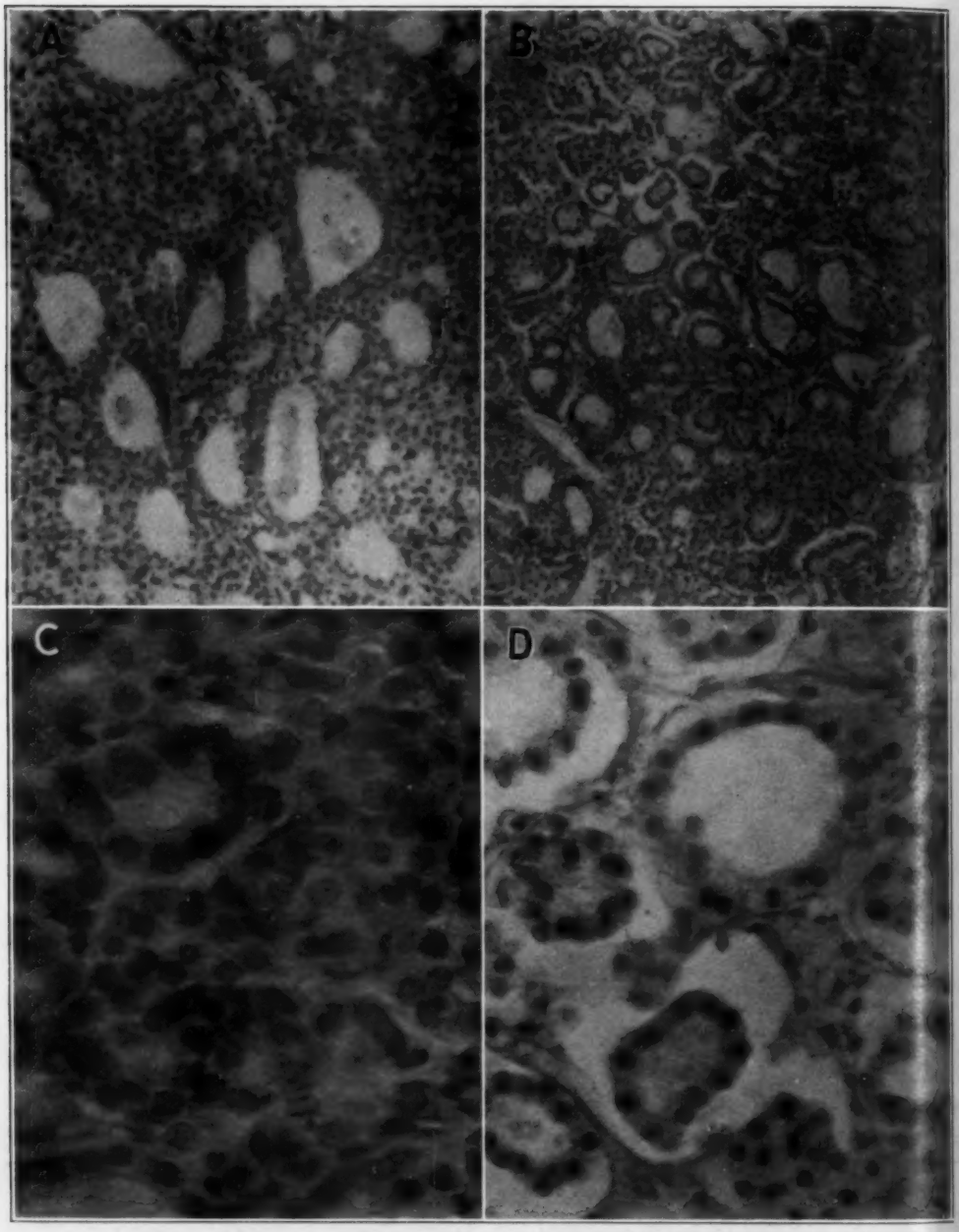

Fig. 1.—*A* and *C*, rabbit 43, group II, isotransplant of one hundred and nineteen days, showing evidence of hyperplasia as compared to *B* and *D*, normal thyroid tissue of a rabbit. Note that the follicles are smaller and more numerous and closely packed, the epithelial cells larger and more cuboidal and the interstitial tissue much diminished. There was also an abnormal abundance of lymphoid tissue, which is not apparent in the field photographed.

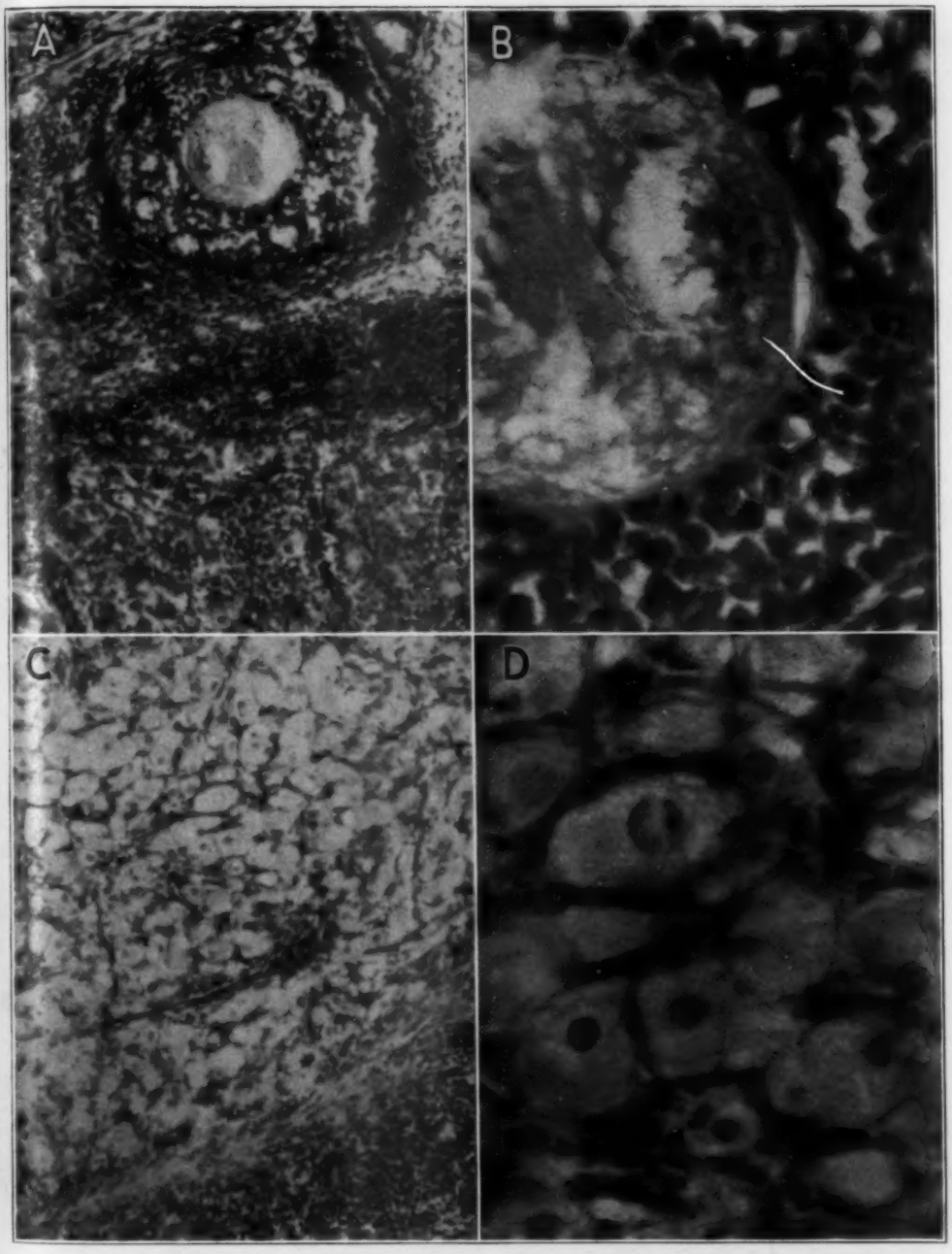

Fig. 2.—Rabbit S 2, group II, ovarian isotransplant one hundred and fifty-nine days after transplantation, showing preservation of its normal histologic structure and evidence of functional activity. *A*, stroma and graafian follicle; *B*, ovum and normal thecal cells; *C* and *D*, low and high magnification of the tissue of the corpus luteum.

2. Three rabbits had daily injections for two weeks. No viable transplants were found, and in 5 instances the grafts had been replaced by fibrous tissue. Myxedema developed in all 3.

3. Two rabbits received daily injections for four weeks, and in 1 both transplants were not only viable but hyperplastic. No signs of hypothyroidism developed in either animal, the takes representing 50 per cent.

C. Repeated Small Injections of the Donor's Blood from Dog to Rabbit: Two rabbits were given daily injections of laked blood for twenty-five days from a dog from which they then received thyroid transplants. None of the 4 grafts survived, and the tissue fifty-five and eighty-six days, respectively, after transplantation was almost entirely necrotic and surrounded by inflammatory tissue. In neither rabbit, however, had myxedema developed.

D. Massive Injections of Blood from the Donor of the Tissue After Transplantation: After receiving transplants 7 rabbits were given 10 cc. of whole blood

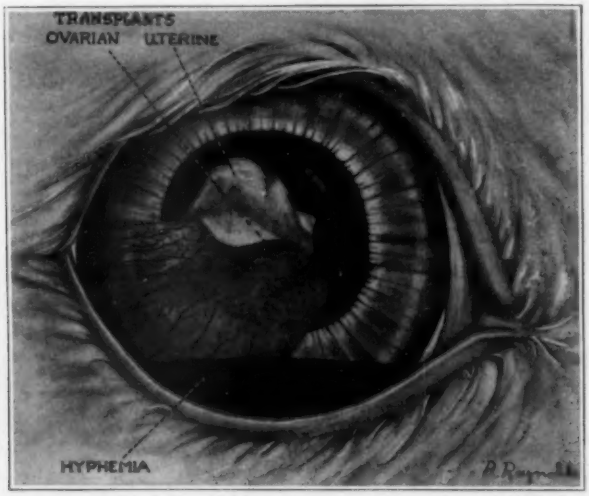

Fig. 3.—Drawing of a utero-ovarian transplant in the anterior chamber, showing the reaction to the injection of 15 cc. of urine of a pregnant woman. (Allan and Priest have reported identical observations.) Note the injection of the iris and the hemorrhage into the chamber. The blushing of the transplant cannot be shown. In the same way transplants of thyroid tissue became attached to the iris and from it received their blood supply.

intramuscularly in a single injection from the animals from which they had received the grafts. These injections were given as follows:

1. Ten cubic centimeters of whole blood to each of 3 rabbits five days after transplantation. Two grafts were viable two hundred and forty-eight days later; 2 were replaced by fibrous tissue, and 2 could not be found, when the animals were examined one hundred and thirty-six and one hundred and twenty days later, respectively. In 1 rabbit myxedema developed.

2. Ten cubic centimeters to 1 rabbit three weeks after grafting. Both grafts were replaced by fibrous tissue.

3. Ten cubic centimeters to each of 3 rabbits six weeks after transplantation. In 1 both grafts survived and were hyperplastic. In each of the other 2 the tis-

sue had been absorbed and replaced by fibrous tissue, and in both signs of myxedema developed.

In this series 29 per cent of the grafts survived.

From this group of experiments it appears that preliminary injections of blood either in a single massive dose or in repeated small injections over a period of less than three weeks serves to sensitize the recipient to the tissue of the donor of the blood, and the grafts fail to take. If the daily injections are continued for three weeks or longer sensitization is lost and the grafts take in a normal percentage of instances. Blood administered after the transplants had established vascular attachments seemed to have exerted a similar influence, though less consistently.

Group VI: Isotransplants After Sensitization and Desensitization of the Donor of the Grafts by Injections of Blood from the Prospective Recipient.—The experiments parallel those of the preceding group with the exception that blood was transferred from the recipients to the donors of the grafts rather than from the donors to the recipients. In other words, the grafts were subjected in their normal habitat to the influence of blood from their future hosts before they were transplanted. In the preceding group the grafts were subjected to no influence before transplantation, but the hosts were prepared in advance of receiving the grafts.

The results in this group likewise paralleled those in the preceding group. Of the 10 grafts from 5 animals which received daily injections for periods of one and two weeks, only 1 survived transplantation, and the epithelial tissue in this instance appeared to be inactive. In this animal and in 3 of the other 4 myxedema developed. Of the 4 grafts from 2 rabbits which received daily injections for four weeks, 1 survived and was definitely hyperplastic. Two grafts could not be found, and 1 had become necrotic and been replaced by fibrous tissue. Myxedema did not develop in either animal.

Group VII: Isotransplants After Sensitization and Desensitization of Both the Donor and the Recipient of the Grafts by Injections of the Donor's Blood to the Recipient and of the Recipient's Blood to the Donor.—In the seventh group of experiments the procedures carried out in the two preceding groups were combined. In other words, not only were the grafts subjected to the influence of blood from their future hosts before they were transplanted, but the hosts likewise were subjected to the influence of blood from the donors of the grafts before receiving them. Twenty rabbits were so treated. Six of them, 3 donors and 3 recipients, received daily injections for one week; an equal number, for two weeks, and 8, 4 donors and 4 recipients, for four weeks. Only 1 of the 20 grafts survived; the donor and the host of this graft had received injections for four weeks. The tissue was definitely hyperplastic, and hypothyroidism did not develop in its host, as it did in 5 of the 10 animals.

Group VIII: Isotransplants After Injections of Nonspecific Blood.—Since, as noted in the foregoing experiments, preliminary injections of specific blood altered the fate of the grafts, the eighth group had for its purpose a test of the influence of nonspecific blood, that is, the influence of small daily and of single massive doses of blood from rabbits which were in no other way related to the experiment. The donor of the grafts neither gave nor received blood. In the 3 animals which received nonspecific blood for one week 3 grafts survived; in

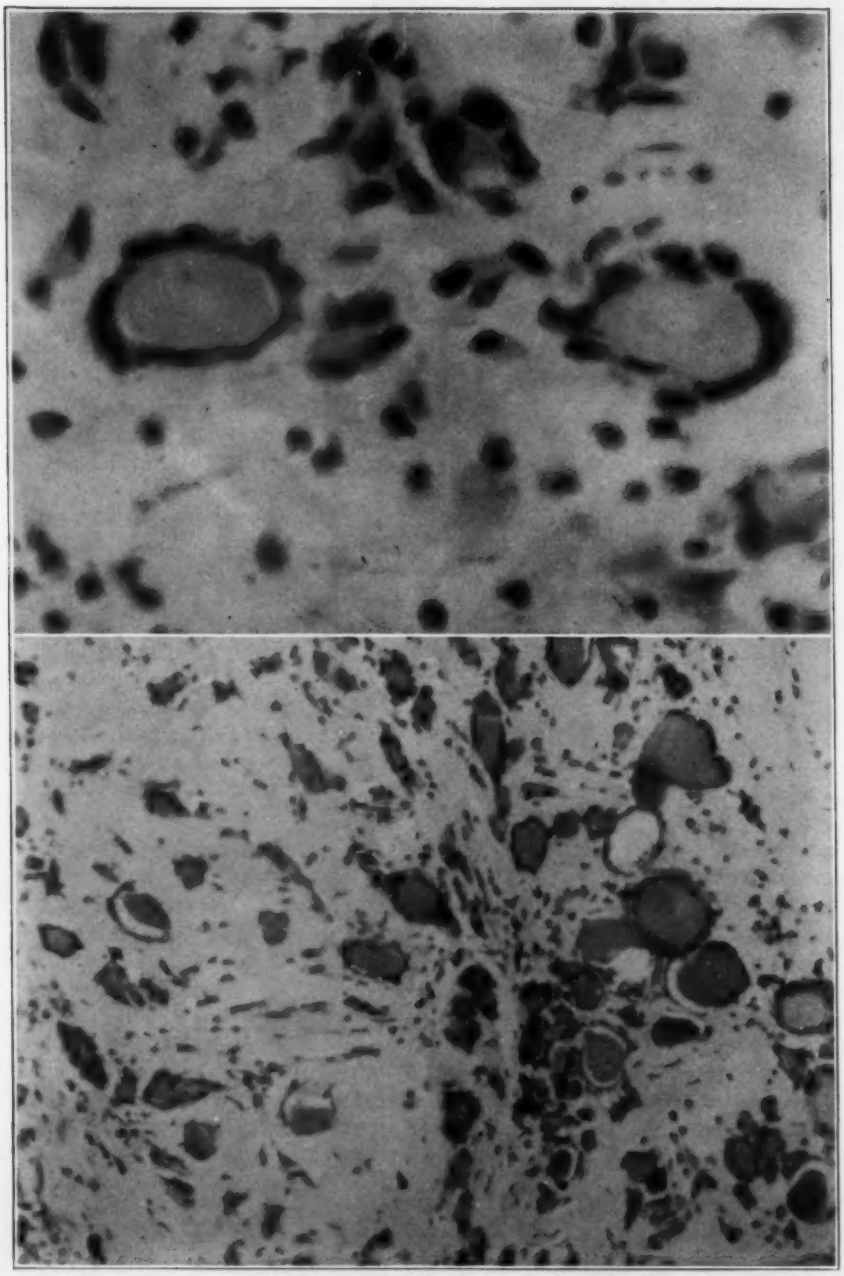

Fig. 4.—Rabbit 88, group VI, isotransplant of one hundred and twenty-one days showing inactive disintegrating thyroid tissue. Only a few follicles lined with flat epithelial cells remain. Most of the tissue has undergone necrosis and has been replaced by fibrous tissue. In this animal myxedema developed, an indication that the transplant was functionally inactive.

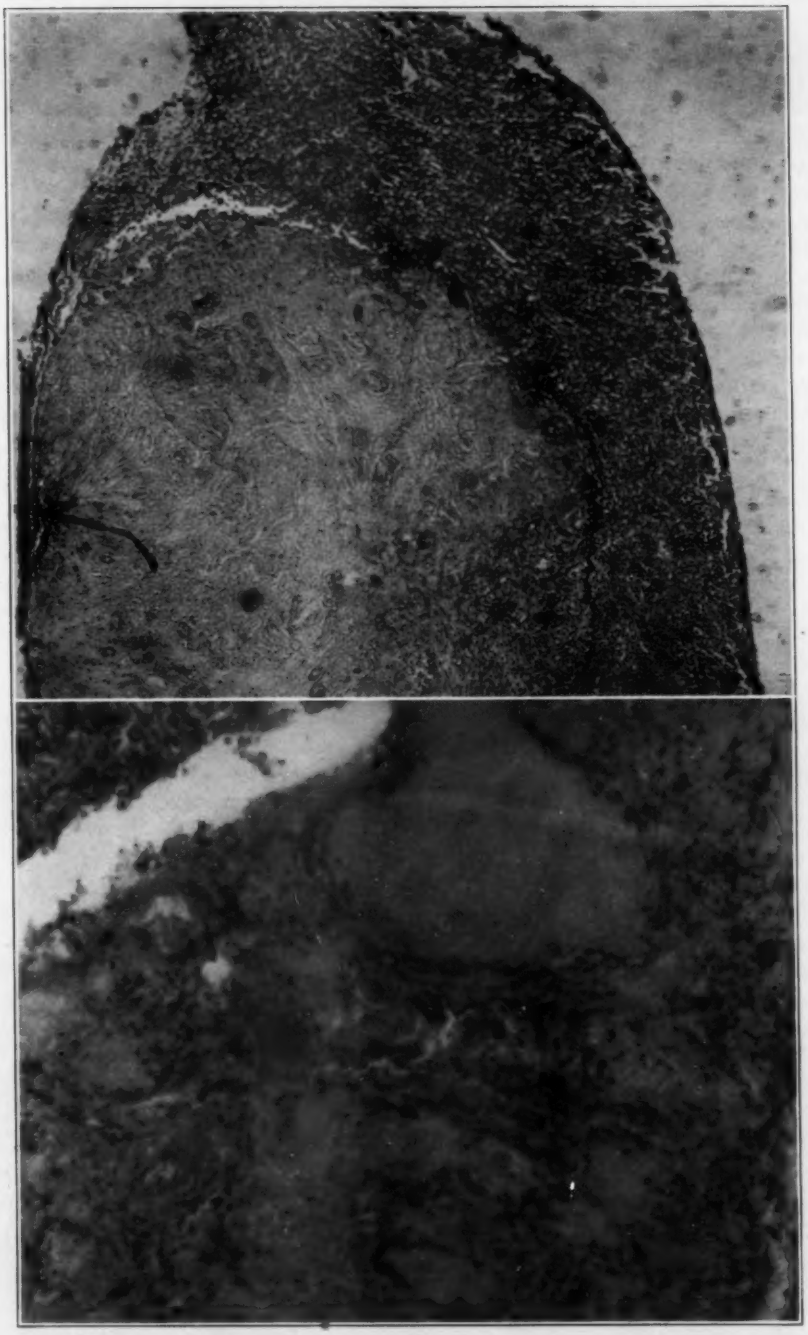

Fig. 5.—Rabbit 96, group IX B, necrotic remains of a transplant of human thyroid to a rabbit. The necrotic mass is adherent to the iris. Some ghost follicles remain. Note the inflammatory reaction in both the iris and the transplant. This is probably a reaction to sensitivity.

the 2 which received it for two weeks 2 survived, and in the 2 which received 10 cc. of whole nonspecific blood seven days after transplantation 3 grafts survived and 2 were hyperplastic. No myxedema developed in this group, although no viable grafts were found in 2 of the rabbits. It appears that nonspecific blood exerted little or no influence on the grafts. Fifty-seven per cent of the grafts survived.

Group IX: Transplants of Human Thyroid Tissue to Rabbits.—In many rabbits of the ninth group rather severe reactions of the eyes developed, and many of them died while receiving injections of blood or within six weeks from the time they received the grafts. The results in this group are based on animals which received no injections of blood and on 4 which survived daily injection of blood from the human donors for four weeks. No viable thyroid tissue was found in any of the postmortem specimens, but in most instances there was necrotic tissue accompanied by slight to moderate inflammatory reaction. Only 1 rabbit lived long enough for myxedema to have developed, and it failed to do so.

Group X: Isotransplants After Preliminary Injections of Extracts of the Donor's Tissue.—In the final experiment one lobe of the thyroid gland was removed from each prospective donor of tissue and macerated; a saline extract was then made of it. The entire extract in each instance was proportioned and given in daily intramuscular injections for periods as outlined. At completion of injections the remaining lobe of the thyroid was removed from each donor and transplanted to the respective recipient of the tissue extract. Three rabbits received daily injections for one week, and of the 6 transplants 1 survived and was hyperplastic and 2 necrosed and were replaced by fibrous tissue. In 1 animal myxedema developed. Eight rabbits had daily injections for two weeks, and of the 16 grafts 3 survived and 10 had become necrotic and been replaced by fibrous tissue. The 3 surviving were hyperplastic. In 3 animals signs of myxedema developed. Four rabbits were given daily injections for twenty-two days. Five of the 8 grafts survived and 4 were hyperplastic. Three had undergone necrosis.

These results suggest that, as in the case of specific blood, the tissue extracts sensitized the animals when administered for less than three weeks but failed to do so when given for a period of three weeks or longer.

COMMENT

It is of interest that an analysis of the results of this investigation shows that transplanted thyroid tissue, though nonviable, delayed the onset of hypothyroidism in totally thyroidectomized animals. As has been stated, it was found in a previous study that in approximately 75 per cent of totally thyroidectomized rabbits signs of thyroid deficiency develop and that these signs appear within eight or ten weeks after expiration of the gland. Of the rabbits which received transplants of thyroid tissue after total thyroidectomy, signs of thyroid deficiency developed, with 1 exception, only in those in which the grafts failed to survive. Signs of hypothyroidism in animals with nonviable grafts, however, appeared not earlier than twelve weeks from the date of thyroidectomy. It would appear, therefore, that the onset of hypothyroidism was delayed by the presence of the grafts despite their failure to survive. Two explanations are possible. Either the grafts

had a temporary take, during which period they functioned, or there was inherent in the tissue and absorbed from it sufficient thyroid principle to delay the onset of signs of deficiency for two or more weeks.

CONCLUSIONS

1. In rabbits heterogenous as well as autogenous grafts not only take in a large percentage of instances but also apparently function.

2. With few exceptions, single massive injections or small daily doses of blood from recipient to donor or vice versa or a combination of both over a period of less than three weeks rendered the recipient or the graft itself sensitive or at least resulted in failure of the graft to take. Although the few exceptions appear to be inconsistencies, they may in reality represent a higher degree of compatability in those particular animals. If the small daily doses were continued for three weeks or longer, desensitization took place or at least there were takes in a much larger percentage of instances; the percentage was smaller, however, than in the animals which received no blood.

3. Thyroid tissue from dogs transplanted to rabbits failed to survive under any circumstances, including daily doses of blood from the canine donors of the tissue for as long as twenty-five days before transplantations were made.

4. Administration of nonspecific blood, that is, blood taken from a third animal, which was otherwise unrelated to the experiment, did not appear to influence the grafts. The percentage of takes and the condition of the grafts were comparable to those in animals which received no blood.

5. Human grafts in rabbits uniformly failed to survive. Preliminary daily doses of the donor's blood for as long as twenty-eight days seemed not to alter the fate of the transplants. Even the rabbits failed to survive very long. Several died while receiving blood, and the survivors died within a few weeks after receiving the grafts. The eyes of the hosts showed rather marked inflammatory reactions both grossly and microscopically.

6. As in the case of blood, preliminary administration of an extract of a graft for periods of less than three weeks sensitized, and for longer periods desensitized, the recipient or at least altered the percentage of takes accordingly. This effect, however, was less consistent than in animals given blood.

Dr. P. C. Tollman, Assistant Professor of Clinical Pathology, University of Nebraska, examined histologically and gave his opinion on all grafts recovered. Drs. J. M. Ferris and E. L. Boegler assisted with the preparation of the animals and the conduct of the experiment. Miss Mildred Braden prepared the tissue sections for histologic examination.

ATYPICAL CARCINOMA OF THE LARGE INTESTINE

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The present study was undertaken primarily in order to supply clinical data supported by pathologic findings on the existence of malignant tumors of the large intestine which pursue an atypical course and render clinical diagnosis difficult. The classic syndrome of constipation alternating with diarrhea, blood in the stools, loss of weight and palpable abdominal tumor leads one to suspect carcinoma of the large bowel, but it does not cover the entire situation. By no means do all malignant tumors of the colon present this syndrome. Autopsies repeatedly disclose the fact that many such tumors are symptomatically silent throughout life; on the other hand, they do at times initiate acute symptoms which threaten the life of the patient unless they are accurately diagnosed and prompt, efficient treatment is rendered. The present investigation covers 45 necropsies at which unusual types of carcinoma of the large intestine were observed. The cases reported have been selected from the records of the Jewish Hospital of Brooklyn.

Age and Sex.—The ages of the patients in this series ranged from 28 to 82, averaging 55. The age period of greatest frequency was from 45 to 65 years. In 29 cases, or about 64 per cent of the total number, the lesions occurred in these two decades, and in 40 cases, or about 90 per cent, they occurred between the ages of 39 and 71. These figures are in accord with the records collected from the literature, and they are also in harmony with the general incidence of cancer in any organ of the body. There were 21 males and 24 females, a ratio of approximately 1 : 1, with a slight preponderance of female patients.

Pathogenesis.—Twelve patients in this series, or 27 per cent of the total number, presented (in addition to carcinoma) single or multiple polypoid growths in the large bowel. The frequency with which polyps appear in the colon is in itself sufficient justification for the prolonged investigations of conditions of that region which might be thought to predispose to carcinoma. It is claimed by many that there exists a direct relation between the presence of polyps and the occurrence of carcinoma of the large bowel. According to Rankin:[1]

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1. Rankin, F. W., and Grimes, A. E.: Diffuse Adenomatosis of the Colon, J. A. M. A. **108**:711 (Feb. 27) 1937.

Polyps of the intestine are usually multiple and widely distributed, often extending from the anus to the cecum, but having a tendency to appear approximately eight times more frequently in the rectosigmoid and rectum than in any other section of the colon. This is particularly significant in the light of the similar occurrence and ratio of the distribution of cancer of the colon and immediately suggests a relationship.

The best proof of the association of polyps with carcinoma of the bowel would be the development of carcinoma on a neglected polyp or a polyp which has been kept under observation; this has been reported by numerous observers. Erdmann and Morris [2] have repeatedly been able in a study of gross specimens in their cases to demonstrate in the same gross specimen all morphologic gradations, from simple polyps, through early infiltrative tendencies, up to frank and unquestioned adenocarcinoma. The practical difficulty, however, lies in the fact that such a lesion when observed is not likely to be left untreated with this possible risk, so that the sequence of events is often difficult to prove. It is likely that when carcinomatous changes do occur the process spreads so rapidly by the inherent penetrative malignancy of the affected cells that it soon blots out any precancerous appearance which might have been present. Allowing for these reservations, it is likely that polyps of the large bowel may be considered the pathologic connecting link between benign neoplasms on the one hand and carcinoma on the other and that it is in the large proportion of cases in which polyps develop that carcinoma is most likely to occur. The practical importance of this does not need stressing. If the physician can identify polypoid changes which are not yet carcinomatous but are likely to proceed in that direction, early removal of the growth will save the patient from the terrors of cancer; this represents prophylactic surgical intervention in the best sense. Unfortunately, however, one is handicapped at the outset by the fact that one may be dealing with a process unapproachable by the ordinary route, so that efficient surgical treatment is hazardous.

It is believed that intestinal irritation resulting from chronic inflammation, such as is seen in cases of chronic colitis, dysentery or tuberculosis, may also be a predisposing factor in the development of carcinoma of the colon. According to Ewing, the transition from simple inflammatory hyperplasia to a tumor which is morphologically, pathologically and clinically adenoma or carcinoma, can clearly be demonstrated. Frequently, a polypoid growth will develop at the site of a chronic inflammation of the colon, and this in turn may eventually give origin to a carcinomatous growth in the bowel. Irritation of the large bowel may also result from prolonged and continuous stagnation

2. Erdmann, J. F., and Morris, J. H.: Surg., Gynec. & Obst. **40**:460 (April) 1925.

of dried intestinal residue, such as is likely to occur in cases of chronic constipation; this in turn may pave the way in certain cases for development of malignant neoplastic changes of the bowel.

Location and Pathologic Picture.—Table 1 shows the various locations of malignant tumor in our series and needs no special comment except emphasis of the fact that in 26 cases, or 58 per cent of the total number, the rectosigmoid alone was involved.

Furthermore, the occurrence of polyp of the colon was most frequently observed in association with carcinoma of the rectosigmoid, which again emphasizes the close relation probably existing between polypoid growths and carcinoma of the colon. Most of the carcinomas observed in this series were of the cylindric cell type with a tendency toward adenomatous formation. Many of the growths were bulky and cauliflower-like, projecting into the lumen of the intestine on the one hand and on the other infiltrating the depths of the wall. Ulceration and necrosis

TABLE 1.—*Location of Lesion*

Site of Lesion	Total Number	Percentage
Cecum	4	9.0
Cecum and ascending colon	1	2.2
Cecum and transverse colon	1	2.2
Ascending colon	3	6.6
Hepatic flexure	2	4.4
Transverse colon	5	11.1
Splenic flexure	3	6.6
Rectosigmoid	26	58.0

were common features of such tumors, and in a number of instances the necrosis involved the entire thickness of the wall, resulting in perforation and in the spilling of intestinal contents into the peritoneal cavity. This, in turn, led to the development of either local or generalized peritonitis. It may be of interest in this connection to cite several cases which have been observed in this hospital.

REPORT OF CASES

CASE 1.—The patient was a woman aged 29, who was admitted to the hospital because of acute generalized abdominal pains of one week's duration. She had apparently been in good health prior to this attack. Physical examination at the time of her admission revealed a very sick woman. The abdomen was distended, rigid and tender. A diagnosis of general peritonitis, probably caused by rupture of the appendix was made. At operation the peritoneal cavity was found to be filled with purulent material, and consequently no attempt was made to ascertain the primary site of the lesion. The peritoneal cavity was drained, but the patient died shortly afterward. At necropsy the peritoneal cavity was observed to be filled with pus. The sigmoid flexure was the seat of a large, ulcerative cauliflower-like mass with a large central perforation through which seepage of intestinal contents took place into the free peritoneal cavity. Microscopic examination of the tumor proved it to be an adenocarcinoma.

CASE 2.—A man aged 58 was admitted to the hospital because of acute abdominal pains of two days' duration. Except for constipation, with which he had been troubled for the past two years, the patient had enjoyed good health until the onset of the present illness. On admission to the hospital he was acutely ill, and the abdomen was distended and tense. A diagnosis of acute intestinal obstruction was made, but he died before surgical intervention could be undertaken. At necropsy a perforated, ulcerative growth of the sigmoid was observed, together with generalized peritonitis. In addition to the carcinoma, multiple polyps were present in the small and large intestines. There was no evidence of metastasis. Histologically the tumor of the sigmoid was found to be an adenocarcinoma.

CASE 3.—The patient, a man aged 49, was admitted to the hospital because of abdominal pains and vomiting of three days' duration. Prior to the onset of the present illness he had had comparatively good health. A few days previously he had noticed abdominal distention, constipation and obstipation. None of the symptoms was relieved by cathartics or enemas. At operation a perforated carcinoma of the sigmoid was found. The patient died soon after operation, and at autopsy generalized peritonitis was observed, resulting from a perforated carcinoma of the sigmoid. No metastasis was observed.

CASE 4.—A 55 year old woman was admitted to the hospital because of acute abdominal pains and vomiting of one day's duration. For nine or ten months prior to admission she had had episodes of constipation alternating with diarrhea, but no other symptom referable to the intestinal tract had been noticed. On examination she appeared acutely ill and presented a large mass in the pelvis, which was thought to be an ovarian cyst with a twisted pedicle. At operation the mass felt in the pelvis proved to be an encapsulated collection of pus, and this was drained. The patient soon succumbed, however, to infection, and at autopsy a perforated carcinoma of the sigmoid was observed. Localized pelvic peritonitis was present. Microscopic examination of the tumor showed it to be an adenocarcinoma. There was no evidence of metastasis anywhere in the body.

These cases illustrate the almost complete lack of symptoms presented by carcinoma of the large intestine and the acute, fulminating course which such a lesion may follow. It is also of interest to note that none of the patients in this series showed any evidence of metastasis, and we attribute this primarily to the acuteness of the lesion, which caused death long before metastasis could develop.

In certain rare instances portions of the growth may slough away completely and give rise to severe hemorrhage. In such cases, also, the broken-off tissue may be expelled through the rectum; the tissue thus recovered may be subjected to pathologic examination and the nature of the lesion determined. This occurred with 1 of our patients, a woman aged 71, who suddenly had a profuse intestinal hemorrhage and expelled, in addition to the blood and blood clot, a large mass of partly necrotic tissue. Histologic examination of the expelled specimen proved it to be an adenocarcinoma of intestinal origin.

Perforation of a carcinomatous intestine does not always take place into the free peritoneal cavity; it may take place into an adjoining viscus and then establish a fistulous communication between the per-

forated bowel and the involved viscus. Several such instances occurred in our series, some of which will be cited as examples.

CASE 5.—A 59 year old man was admitted to the hospital because of pain, nausea, vomiting and extreme weakness. He died within a short period, and at autopsy two separate carcinomatous growths were observed, one in the cecum and the other in the transverse colon. The carcinoma in the cecum had perforated into the stomach, producing a fistulous communication between these two organs.

CASE 6.—The patient was a man aged 44, who for ten days prior to his admission to the hospital had been complaining of abdominal pains, nausea, vomiting and weakness. He had episodes of rectal bleeding at varying intervals. On examination the patient appeared acutely ill; the abdomen was tense and transmitted a sense of fulness to the examining hand. He died within a short period after entering the hospital, and at autopsy a carcinoma of the splenic flexure was observed. It had perforated into the stomach, producing a gastrocolic fistula. Widespread metastases to the liver, the spleen and the thoracic duct were observed, together with diffuse chylous peritonitis; the latter condition was due to obstruction of the thoracic duct by tumor tissue.

CASE 7.—Perhaps one of the most interesting cases of this group is the following: A man aged 54 was admitted to the hospital with a complaint of cutting, burning and pressing pains in the pelvis; these pains were aggravated on urination. The symptoms had been present for four months. The patient had been apparently well until six months prior to admission, when he strained considerably at stool and passed a small amount of feces stained with blood. The blood continued to appear in the stools for one week and then stopped. During the next two months he remained well except for constipation, for the relief of which he had to use a considerable amount of liquid petrolatum and castor oil. Four months prior to admission he was suddenly seized with a cutting and burning pain along the penile portion of the urethra; this pain was much worse on urination. He had considerable difficulty in starting the urinary flow, and he began to note for the first time the passage of blood and fecal matter in the urine.

On examination at the time of admission the patient was well developed and fairly well nourished and did not appear acutely ill. The abdomen was scaphoid and soft; a sausage-shaped tumor was palpable in the left lower abdominal quadrant. Rectal examination showed the vesical wall thickened and indurated, and a soft mass could be felt between the bladder and the anterior wall of the rectum. A cystogram showed a free communication between the posterior aspect of the bladder and the anterior surface of the sigmoid. A sigmoidoscopic examination proved entirely unsatisfactory. Cytoscopic examination showed intense generalized cystitis in addition to a large tumor, irregular in outline, situated at an area covering the left lateral wall, the posterior wall and the roof of the bladder. The top surface of the vesical tumor showed some degree of necrosis. Surgical intervention was felt advisable, and at operation the sigmoid flexure was removed together with the bladder, in one mass. The patient, however, failed to recover from the operation and died soon afterward. Pathologic examination of the specimen revealed an ulcerating carcinomatous growth of the sigmoid flexure, which had perforated into the bladder, producing a fistulous tract between the two organs. A secondary metastatic growth was observed, involving the posterior wall of the bladder. Microscopic examination of tumor tissue recovered from both the bladder and the sigmoid flexure showed it to be an adenocarcinoma of intestinal origin.

CASE 8.—Another case, somewhat similar to case 7, is the following: A 52 year old woman had progressive dysuria for four months. She did not complain of symptoms referable to the intestinal tract. On admission to the hospital she appeared well developed and rather obese. There was tenderness in both flanks and in the suprapubic region. Rectal and vaginal examinations gave negative results. The urine gave a 3 plus reaction to the test for albumin. The sugar content of the urine was 1.5 per cent, and clumps of pus and numerous red blood cells were present. The blood count showed: hemoglobin, 90 per cent; erythrocytes, 4,500,000; leukocytes, 9,900, and polymorphonuclears, 80 per cent. The sedimentation rate of the blood was 80 mm. in one hour. The reaction of the stools to the guaiac test was negative. There was 20 cc. of residual urine in the bladder. Culture of the urine showed Bacillus coli; the phenolsulfonphthalein test showed excretion of 69 per cent in two hours. Cytoscopic examination revealed marked cystitis in addition to a large globular mass occupying the right upper vault of the bladder. A biopsy of material from the mass was done, and the pathologic findings were those of an adenocarcinoma, probably of intestinal origin. A cystogram and aerogram showed a large filling defect in the vault of the bladder. At operation a large encircling carcinoma of the sigmoid flexure was found; it had invaded the bladder and the surrounding structures by direct continuity, forming a large frozen and inoperable pelvic mass. There were also a few metastatic nodules in the liver.

This case illustrates the complete lack of symptoms of the primary lesion in the sigmoid flexure in spite of its extensive growth and widespread metastasis. Cytologic examination of a biopsy specimen removed from the tumor in the bladder revealed the fact that the primary site of the growth was in the large intestine and that the tumor in the bladder was secondary.

The other type of tumor frequently encountered in this series was the annular or constricting form. This did not, as a rule, present a bulky mass of tissue growing into the lumen of the intestine, but it infiltrated the depth of the wall, replacing the various intestinal coats. The patients with this type of growth often succumbed rather suddenly to acute intestinal obstruction, which at autopsy proved to have been caused by an adenocarcinomatous stricture of the large intestine. A few such cases will be cited as examples.

CASE 9.—A 28 year old woman was admitted to the hospital with a history of an acute onset of abdominal pains, vomiting and obstipation of thirty-six hours' duration. She was apparently well until three months prior to admission to the hospital, when she first had diarrhea. The condition lasted one week and then subsided. She remained well until the present attack of abdominal pains and vomiting, thirty-six hours before her admission to the hospital. On admission the patient appeared acutely ill; the abdomen was distended, and she was vomiting stercoral material. Her poor general condition did not permit surgical intervention, and she died twenty-four hours later. At autopsy a constricting tumor of the sigmoid was observed, which microscopically proved to be an adenocarcinoma. Numerous polyps of the large intestine were also observed. There were no metastases.

CASE 10.—A man aged 82 was apparently well until four weeks prior to his admission to the hospital, when he began to complain of loss of appetite, loss of weight and vomiting. Two weeks before his admission the stools were loose and black. On examination no abnormality was noticed; the pains and vomiting

soon subsided, and the patient was discharged. He was readmitted seventeen days later because of intermittent gnawing pains in the abdomen. The abdomen was tense and much distended. The patient died two hours after entering the hospital. At autopsy a carcinomatous stricture of the sigmoid flexure was observed. Diffuse peritonitis was also present. There were no metastases.

CASE 11.—A 57 year old woman was admitted to the hospital complaining of nausea and vomiting after meals, sticking pains in the abdomen, borborygmi and constipation. The symptoms had appeared four weeks previously. She had been constipated for a number of years, but in the past four weeks the constipation had become obstinate and had not responded to cathartics or enemas, except to high colonic irrigations. On examination at the time of admission, the abdomen was distended and tympanitic. No masses could be palpated either abdominally or rectally. The patient was operated on for intestinal obstruction, but she succumbed to the operation. At autopsy a constricting adenocarcinoma of the sigmoid was observed.

CASE 12.—The following case is of particular interest: A woman aged 50 was admitted to the hospital because of abdominal cramps and vomiting. She had been in good health until two months prior to admission, when she first noticed slight epigastric distress, which was relieved by sodium bicarbonate. Two weeks later she was seized with severe abdominal cramps associated with vomiting and retching, which subsided after she took an enema. Since then she had had repeated mild seizures of intestinal cramps associated with constipation alternating with diarrhea. There was no blood in the stools. Seven days before entering the hospital she was again seized with excruciating general abdominal pains, and at this time enemas failed to relieve her. Two days later she began to vomit, and she continued to do so at least once daily. She had had no evacuation of the bowels for the last seven days, in spite of the many enemas which she had received.

On admission to the hospital the patient appeared well developed and well nourished but acutely ill and in great distress. The facies was somewhat cyanotic, and the skin was cold and clammy and covered with beads of perspiration. The abdomen was distended and spastic. A questionable mass was palpable in the left upper quadrant of the abdomen, which was firm but not tender. The preoperative diagnosis was acute intestinal obstruction, probably caused by a malignant growth. At operation, a constricting growth encircling practically the entire circumference of the sigmoid flexure was discovered. The sigmoid was resected, and pathologic examination of the specimen revealed an adenocarcinomatous stricture of the sigmoid. The inner surface of the growth adjoining the lumen of the intestine was ulcerated, and lodged within the ulcer was a vertebra of a squab, which caused complete obstruction of the intestine at this point.

COMMENT

In the 45 cases in which necropsy was done the liver was by far the most frequent site of metastasis, with the regional lymph nodes next, and direct infiltration of the peritoneum, the omentum and the adjoining organs last.

Table 2 shows the sites of metastasis in the 45 cases and demonstrates the relatively large percentage of cases in which metastasis occurred. The high proportion of cases in which the liver was involved, almost twice the proportion in which the regional lymph nodes were involved,

leads one to assume that the hepatic spread must be blood borne. Furthermore, of the 16 carcinomas from which metastasis occurred, 11 originated in the rectosigmoid; 8 of these metastasized to the liver. The infrequency of peritoneal seeding in this disease (2 cases) as compared with its frequency in other intra-abdominal malignant diseases is remarkable. Obstruction of the thoracic duct by carcinomatous tissue in 1 of the cases is of interest and explains the development of the chylous peritonitis that was noted.

The presence of two independent carcinomatous lesions in two different organs of the body is also of great interest. One of the patients showed at autopsy a bronchogenic carcinoma in addition to carcinoma of the cecum. Clinically the symptoms presented by this patient pointed to a carcinoma of the lungs; he had no symptoms that pointed to a tumor of the cecum, and the finding at autopsy of a carcinoma of the cecum as well as a bronchogenic carcinoma was rather surprising.

TABLE 2.—*Sites of Metastasis*

Metastasis	Total	Percentage
Total cases	16	35.5
Liver	10	62.5
Regional nodes	6	37.5
Peritoneum	2	12.5
Omentum	2	12.5
Ovary	1	6.2
Diaphragm	1	6.2
Lungs	1	6.2
Kidney and pancreas	1	6.2
Spleen and thoracic duct	1	6.2

In another case a diagnosis of carcinoma of the ovary was rendered, but at autopsy, in addition to a carcinoma of the ascendnig colon, a carcinoma of the ovary was observed, cytologic examination of which proved it to be adenocarcinoma of different cell origin.

Perhaps one of the most unusual cases in our series was that of a patient in whom carcinoma of the rectum developed while he was under treatment for lead poisoning. This case has already been reported by Gray and Greenfield [3] from this hospital. The following is a brief summary: A man aged 51 was exposed to the inhalation of lead fumes in an enclosed chamber and later had abdominal colic associated with weakness, anorexia and constipation. Because of the progressiveness of the symptoms he had to stop work five months after having been first exposed to the lead fumes. Physical examination revealed marked pallor but no other unusual finding. The blood showed a moderate degree of anemia and stippling of the red blood cells. All other laboratory examinations were reported as giving negative results. Delead-

3. Gray, I., and Greenfield, I.: New York State J. Med. **37**:649 (April 1) 1937.

ing therapy was instituted, and the patient began to excrete lead in the stools and in the urine. The abdominal colic disappeared, and the function of the bowel returned to normal. Four months after cessation of exposure to lead, profuse rectal bleeding occurred. Rectal examination revealed a hard, irregular mass occupying the anterior wall of the rectum, just above the prostate. The patient was operated on for excision of the tumor, but he succumbed to the operation three weeks later. Pathologic examination of the specimen obtained from the rectum proved it to be an adenocarcinoma.

A search through the literature reveals numerous descriptions of the symptoms of carcinoma of the colon, but the difficulty is that they usually have no application to the particular case. It is emphasized that many carcinomatous lesions of the colon mimic other intra-abdominal conditions and offer no evidence of an existing intestinal lesion. This is particularly true of the acute, fulminating forms of malignant tumor, which often advance to perforation or obstruction before the true nature of the lesion can be discovered.

It is still a general belief that carcinoma of the colon is often associated with constipation and diarrhea and that these symptoms are rather pathognomonic of the lesion. An analysis of the various symptoms presented by this group of patients with carcinoma of the colon shows that constipation and diarrhea, which were noted in 27 and 9 cases respectively, were probably no more frequent among our patients, than they are among presumably normal persons of the same age. Diarrhea was less common than constipation and probably has no value as a diagnostic sign. The simultaneous occurence of diarrhea and constipation was even less frequent; it occurred in only 5 cases of the series. Pain was a frequent complaint and occurred in 42 cases, but considering the fact that in most cases the condition ran a very acute course and was frequently complicated by intestinal obstruction and peritonitis, such pain cannot be regarded much longer as symptomatic of carcinoma of the colon. Nausea and vomiting occurred in 17 cases; in 11 of these, autopsy revealed a carcinomatous stricture with intestinal obstruction or a carcinomatous perforation of the bowel with peritonitis. Undoubtedly, the nausea and vomiting were caused rather by the peritonitis or intestinal obstruction than by the tumor per se, as in 28 cases in which no complicating factors were present there was no nausea or vomiting. Only 15 patients, or one third of the total number, presented a palpable mass in the abdomen on either rectal or abdominal examination. In some cases the palpated mass was tender, while in others it was painless. The presence of blood in the stools was noted in 11 cases. In 2 instances the bleeding was profuse, and in another it was associated with the expulsion of a mass of tumor tissue, largely necrotic. In 1 case bleeding appeared through the urethra because of a sigmoidovesical

fistula. In 2 the blood was mixed with mucus, and in 3 it was black and was recorded as melena. In 20 cases there was no history of loss of weight; in 1 the loss of weight was reported as amounting to 80 pounds (36.3 Kg.), while in several cases it averaged 20 pounds (9.1 Kg.). On the whole, loss of weight was not a striking feature. Weakness was noted in 25 cases, but this, again, might have been due to the acuity of the lesion and the complicating factors that were noted in so many of our reported cases. In about half the cases the patients were well developed and well nourished and appeared fairly healthy.

The duration of symptoms referable to the intestinal tract was variable in the different cases studied. Many patients had vague symptoms suggestive of intestinal disturbance which extended over two years and more but which terminated in an acute episode lasting for periods varying from a few hours to several days. The average duration of symptoms before the patient sought the advice of a physician was about six months. Our data are not sufficiently detailed to permit conclusions as to the roentgenologic or proctoscopic findings in cases of malignant tumor of the large intestine. Many of the patients were acutely ill on entering the hospital, and roentgenologic or proctoscopic examination was inadvisable. Therefore, no consideration of such accessory aids in the diagnosis of carcinoma of the colon was undertaken in this series of cases. Allowing for such reservations, it may be said that patients with a palpable tumor, loss of weight, bleeding from the rectum and signs of intestinal obstruction or perforation probably were all at the stage at which nothing could be done to help them. The disease was far advanced before they had any reason to suspect its existence.

SUMMARY AND CONCLUSIONS

Forty-five cases of atypical carcinoma of the large bowel, with autopsic observations, are reported. The symptoms presented by most of the patients were indistinguishable from those of other acute intra-abdominal conditions and rendered clinical diagnosis very difficult.

Among the cases reported in this series, perforation and obstruction of the carcinomatous bowel were commonly observed. In 1 case the obstruction was caused by a foreign body lodging in the sigmoid at the site of the growth. In 2 cases the tumor invaded the urinary bladder and gave rise to urinary symptoms alone, but biopsy of material from the tumor in the bladder proved it to be of intestinal origin. In 1 case carcinoma of the colon was associated with a bronchogenic carcinoma, in 1 with an ovarian carcinoma and in 1 with lead poisoning.

In 27 per cent of cases the tumor in the bowel was associated with a polypoid growth in the intestine.

The symptoms of carcinoma of the large intestine are readily confused with those of other intra-abdominal conditions.

OVARIAN TUMORS AND DIAGNOSIS OF ACUTE APPENDICITIS

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An analysis of a large group of cases of ovarian tumor (1,101 cases) disclosed that 103 laparotomies were performed after a diagnosis of acute or chronic appendicitis had been made. That disease of the ovary may simulate appendicitis, disturbances of the gallbladder or genitourinary tract, ectopic gestation and other abdominal or pelvic conditions is well known. Generally the symptoms of an ovarian growth differ sufficiently from those of appendicitis to warrant careful differentiation before radical treatment is instituted. The salient features of ovarian tumor and the clinical and operative findings as here disclosed may serve to indicate the causes of the high incidence of diagnostic error.

Physicians often examine a normally menstruating, unmarried young woman to determine the cause of pain in the lower part of the abdomen. I have found that the incidence of ovarian pathologic change in such patients is especially high.

Sixty-three patients (61 per cent) were under 20 years of age; 37 (36 per cent) were between 20 and 30, and only 3 (3 per cent) were over 40. Most of them were single (64 per cent). Although ovarian structure was altered in all the cases, menses were normal in 83 per cent. In 11 per cent of cases there was metrorrhagia; in 5 per cent there was secondary amenorrhea; and in 1 per cent there was primary amenorrhea. Although dysmenorrhea occurred in 25 per cent of the patients, this symptom was predominant only among patients under 20 years of age.

The syndrome of recurrent severe or mild interval pain (*Mittelschmerz*) is commonly found in the histories of such patients. The intermenstrual incidence, periodic recurrence and short duration of the pain are significantly constant. It was interesting to note that 70 per cent of the patients in this series had histories of repeated attacks of pain in the lower part of the abdomen, which always occurred during the menstrual interval. More than half the patients had had over five attacks. In several instances the attacks dated back to the onset of the menses; other instances of interval pain for three to five years are reported, but the majority (80 per cent) had noticed repeated pain in the lower part of the abdomen for only four to ten months. Twelve patients were operated on at the time of the first attack.

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The severe onset persisted usually for six to twelve hours but subsided into a low grade pain which disappeared gradually in one week. Several instances of continuous, annoying interval pains terminating in intolerable dysmenorrhea were also noted. There were also single instances of spontaneous colicky pain occurring for the first time, which nothing but morphine could relieve. Although nausea and vomiting were frequent, the patients did not abstain from eating.

Since involvement of the right ovary brings up the question of appendicitis, the following findings are noteworthy. Structural changes in the right ovaries of 82 per cent of these women were noted. In 10 patients the left ovary was involved, and in 7 both ovaries showed changes; disease of the appendix was found in only 4 cases.

The rare phenomenon of unilateral pain produced by diseased tissue of the contralateral side is well known. This analysis indicates, however, that with regard to the ovary the phenomenon is not as rare as is commonly supposed. In 20 per cent of the patients the site of the pain was contralateral to the affected ovary. However, in most of the patients (68 per cent) who complained of pain on the right side with or without pain in other areas the right ovary alone was involved; and in several instances bilateral ovarian disease was found. Not always does bilateral pain in the lower quadrants of the abdomen manifest bilateral ovarian disturbance; in 9 instances a tumor of the right side of the pelvis and in 2 instances a tumor of the left side of the pelvis was the site of origin of bilateral pain. Only in 1 instance, however, was disease of the ovary bilateral.

Although all the histories indicated that the clinical onset in both acute and chronic conditions was sufficiently severe to warrant operation for appendicitis, the operative findings revealed a striking absence of appendical disease in all but 7 patients.

The findings are derived from two groups, namely those patients for whom chronic attacks of appendicitis were reported and those in whom the onset was severe enough to be classified as acute appendicitis.

There were 45 patients with chronic appendicitis; for these patients the findings were as follows: One patient had ovarian endometriosis and tuberculous adnexitis; 1 had an endometrial cyst of the ovary; 25 had follicular cysts, none of which showed rupture; 9 had corpus luteum cysts; 8 had polycystic ovaries, and 1 had a hydrosalpinx on the right side with a simple ovarian cyst (this patient also had a carcinoid of the appendix).

In this group only 1 instance of an appendical lesion was found; in the same patient, however, a hydrosalpinx on the right side and a simple ovarian cyst were sufficient to cause the symptoms. Thus, except for the 2 cases of endometriosis, simple cyclic ovarian changes such

as follicular and corpus luteum cysts produced symptoms of chronic appendicitis.

There were 58 patients for whom a diagnosis of acute appendicitis was made and the onset characterized as severe. All lesions found in this group were related to the ovary, but 6 appendical lesions were also found. Two of these, namley, foreign body and oxyuriasis of the appendix, were accompanied by ovarian torsion, which, it may be fairly assumed, produced the acute symptoms. Appendical lesions with suppuration or gangrene undoubtedly accounted for the symptoms of the remaining 4 patients, even though ovarian pathologic change was also present.

The following lesions were found at operation: 37 follicular cysts, 12 ruptured and 1 gangrenous (there were 3 suppurative appendixes in this group); 9 corpus luteum cysts, 5 of which showed rupture; 9 dermoid cysts, 4 with torsion (there was 1 gangrenous appendix in this group); 1 bilateral microcystic ovary (the patient was psychneurotic); 1 parovarian cyst, and 1 instance of ovarian endometriosis of the ovary with uterine pregnancy.

Thus, for these 58 patients operated on for acute appendicitis only 4 appendical lesions were found severe enough to warrant such a diagnosis. Not even all the ovarian changes, although present throughout, were sufficient to produce symptoms indicating immediate surgical intervention. Ordinarily a simple follicular or corpus luteum cyst is not of surgical significance, and it is noted also that two thirds of the follicular cysts and half of the corpus luteum cysts were unruptured. Microcystic ovaries, although occurring in a psychoneurotic patient, generally do not simulate acute appendicitis. The dermoid, parovarian and endometrial cysts, however, all indicated operation.

SUMMARY

1. In 45 patients whose condition was diagnosed as chronic appendicitis no pathologic change was found in the appendix to warrant this diagnosis.

2. In 58 patients whose condition was diagnosed as acute appendicitis, only 4 appendical lesions were found indicating operation.

3. About 32 per cent of all ovarian lesions were severe enough to account for the appendicitis syndrome. (These included ruptured follicle cysts, endometriosis, dermoids and torsion.)

4. Eighty-nine per cent of the ovarian changes were purely cyclic or functional (follicular cysts, microcysts and corpus luteum cysts) conditions ordinarily requiring no operation; 26 per cent of these, however, were ruptured.

5. Twenty-three per cent of patients whose condition was diagnosed as appendicitis were found to have acute onset of pain, caused by torsion, by rupture, by gangrene or by an ovarian tumor (all types).

6. Ovarian disease accounted for 96 per cent of abnormal operative findings. Appendical disease represented only 4 per cent. Thus, the appendix was a direct cause of the syndrome diagnosed as appendicitis in only 4 per cent of patients in this group; a 96 per cent error was made in diagnosis.

7. Operative findings warranting surgical intervention aggregated 14 per cent. (These included appendical and ovarian pathologic conditions, such as dermoid, endometriosis, hydrosalpinx and tuberculous adnexitis.)

8. The high incidence of unmarried patients (64 per cent) and normal menstrual histories (83 per cent) as well as the incidence of dysmenorrhea (25 per cent) is of interest.

Significant as causes for diagnostic error are the 20 per cent frequency of pain which occurred contralaterally to the site of disease and the 78 per cent incidence of involvement of the right ovary which produced pain in the right lower quadrant of the abdomen, similar to that of appendicitis.

The youth of the patients (88 per cent under 30 years of age) and the repeated attacks of interval pain (*Mittelschmerz*) in 70 per cent, as well as the rapidly subsiding symptoms, are sufficient reasons for proceeding slowly before operation is undertaken in such cases.

The symptom of acute pain in the right lower quadrant of the abdomen in an unmarried female patient under 30 years of age may closely simulate appendicitis, but a painstaking history and a twenty-four hour period of careful observation will in many instances spare the patient an unnecessary operation.

A NEW SURGICAL MASK

A BACTERIOLOGIC AIR FILTER

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There is ample evidence in recent surgical literature to show that surgeons are not satisfied with the present methods of face masking. Walker [1] in 1930 outlined what he considered the requirements of an ideal mask and hastened to state that he had not yet found it. Waters [2] in 1936 pointed out that improper surgical masking has constituted a persistently weak link in the chain of aseptic operative technic. Walker in 1935 presented bacteriologic evidence as to the source of hemolytic streptococci in four epidemics in hospitals, three in surgical services and one in an obstetric service. Cultures of material taken from hands, instruments, solutions and sterile goods at the time of these epidemics failed to show hemolytic streptococci. The masks were found to be ineffective and half of the operating room personnel were found to be carriers of hemolytic streptococci. Meleney [3] in 1935 studied the bacterial flora of the air in his operating rooms and estimated that from 35,000 to 60,000 bacteria fall on the sterile operative field during the course of one hour. Davis [4] in 1937 stated:

> In short, I feel that adequate masking is not only essential but is the most important, in addition to rubber gloves and gentle handling of tissues, that the surgeon can personally carry out to prevent infection in clean operative wounds.

Blatt and Dale [5] in 1933 advocated the use of impermeable deflector masks. These are not filters. Waters in 1936 described a similar impervious deflector mask.

From the Department of Bacteriology and Public Health, the University of Illinois College of Medicine.

1. Walker, I. J.: How Can We Determine the Efficiency of Surgical Masks? Surg., Gynec. & Obst. **50**:266, 1930.
2. Waters, E. G.: Adequate Surgical Masking: Problem and Solution, Am. J. Surg. **32**:474, 1936.
3. Meleney, F. L.: Infection in Clean Operative Wounds, Surg., Gynec. & Obst. **60**:264, 1935.
4. Davis, J. S.: Is Adequate Masking Essential for the Patient's Protection? Ann. Surg. **105**:990, 1937.
5. Blatt, M. L., and Dale, M. L.: A Bacteriological Study of the Efficiency of Face Masks, Surg., Gynec. & Obst. **57**:363, 1933.

Gardner, Hart and Durham [6] in 1937 ably and comprehensively reviewed the recent literature in regard to advances in surgery from a bacteriologic point of view.

Eight years ago I had occasion to study the relative effectiveness of textiles as to their power to absorb bacteria. Among the materials used were silk, linen, cotton and wood cellulose in the form of a creped wadding called cellucotton. These materials were teased out into single fibers; the fibers were submerged in suspensions of bacteria and then were removed and washed three times. Centrifugation was used between washings to recover the fibers, which were then fixed on slides and stained. Figure 1 is a photomicrograph of cellucotton, cotton and linen treated in this manner. Staphylococcus aureus was the organism used. Figure 2 is a high power photomicrograph of the cellucotton fibers showing the staphylococci on the topmost fiber.

A member of the surgical staff came to me several months ago for help and suggestions as to the problem of reducing the hazards of transmitting in operating rooms the bacterial flora of the upper part of the respiratory tract. We have studied this from two standpoints; first, the temporary reduction (for a period of two hours) of bacterial flora in the mouths and throats of the operating room personnel, and second, the investigation of masks to filter out the expelled flora. The latter subject will be reported in this paper. The first problem is still being studied. We have, however, some encouraging results, and we hope to be able to report something of practical value within a few months.

We were not concerned with deflecting bacteria from the operative field but desired to filter out the bacteria from the expired air. Our work has been made possible by the use of the air centrifuge of Wells.[7] This useful apparatus allows the investigator to count the bacteria per unit of air in a manner similar to that in which one counts bacteria per unit of any fluid, such as water or milk. We could not have carried out these studies if we had used the old open Petri dish method for bacterial counts. Wells has produced a small, compact, practical machine. I do not desire to take up space describing this useful apparatus. The quantity of air to be analyzed is pulled into this machine by a suction fan, and the bacteria are deposited by centrifugal power on the surface of a glass cylinder coated with the desired agar medium, plain agar, blood agar or chocolate agar. The heavier particles settle first and are at the bottom of the cylinder. The size of the particles containing the bacteria, such as droplets of expelled exudate or saliva,

6. Gardner, C.; Hart, D., and Durham, N. C.: Recent Advances in Surgery from a Bacteriologic Viewpoint, Surgery **1**:458, 1937.

7. Wells, W. F.: On Air-Borne Infection: II. Droplets and Droplet Nuclei, Am. J. Hyg. **20**:611, 1934.

can be accurately determined by a reading of the results after incubation of this cylindric tube coated with a culture medium. The heavy particles are on the bottom; the bacteria, free of accompanying pus and mucus, are toward the upper end of the tube. We are using this apparatus for various purposes associated with routine surgical and obstetric service. The instrument and the technic yield exact information relative to many environmental conditions which have been considered in the past but owing to lack of accurate technical methods have been more theoretic than practical.

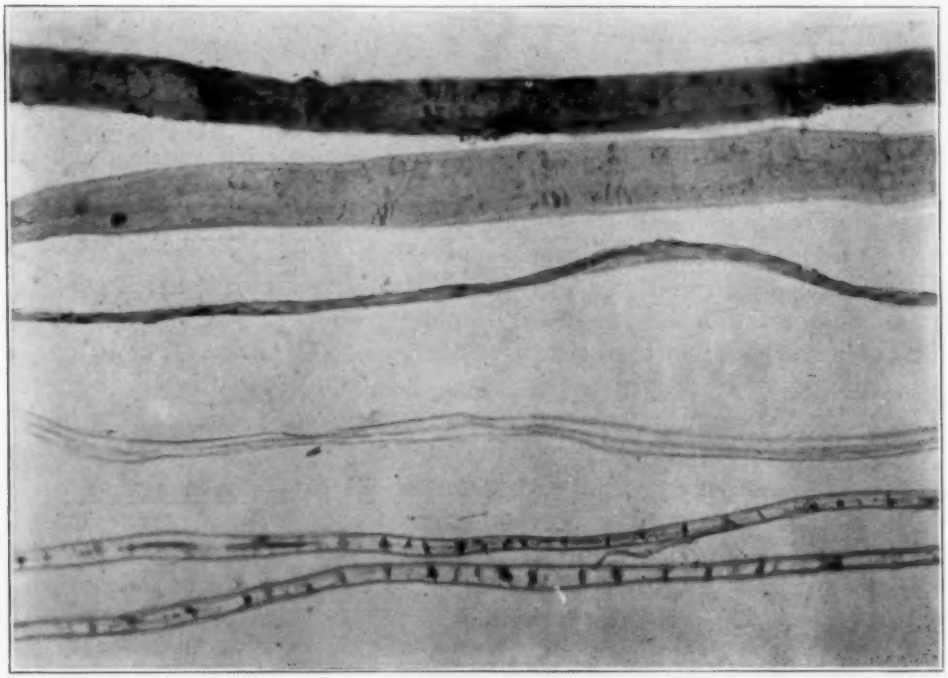

Fig. 1.—Photomicrograph of cellulose, cotton and linen fibers. The upper two larger fibers are cellulose. The uppermost fiber has been in contact with a suspension of bacteria and has been washed three times. Note the large number of bacteria still adhering to the fiber. The next large fiber is of clean untreated cellulose. The middle two fibers are cotton; the upper one of these two was treated the same as the top cellulose fiber. There are few bacteria remaining on this fiber. The fourth fiber from the top is a control, an untreated cotton fiber. The lower two fibers are linen. The bottom fiber is the control; the fiber above it has been in contact with bacteria the same as the topmost cellulose fiber. Few bacteria can be observed on this linen fiber.

Hart [8] in 1937 recommended sterilization of the air in operating rooms by bactericidal radiant energy. This is another approach to the

8. Hart, D.: Sterilization of the Air in the Operating Room by Bactericidal Radiant Energy, Surgery **1**:770, 1937.

problem of controlling the transmission of flora of the upper part of the respiratory tract in surgical procedures. The reports so far of the use of this method seem encouraging, but it is still experimental and has not been accurately standardized. The recirculated and incoming

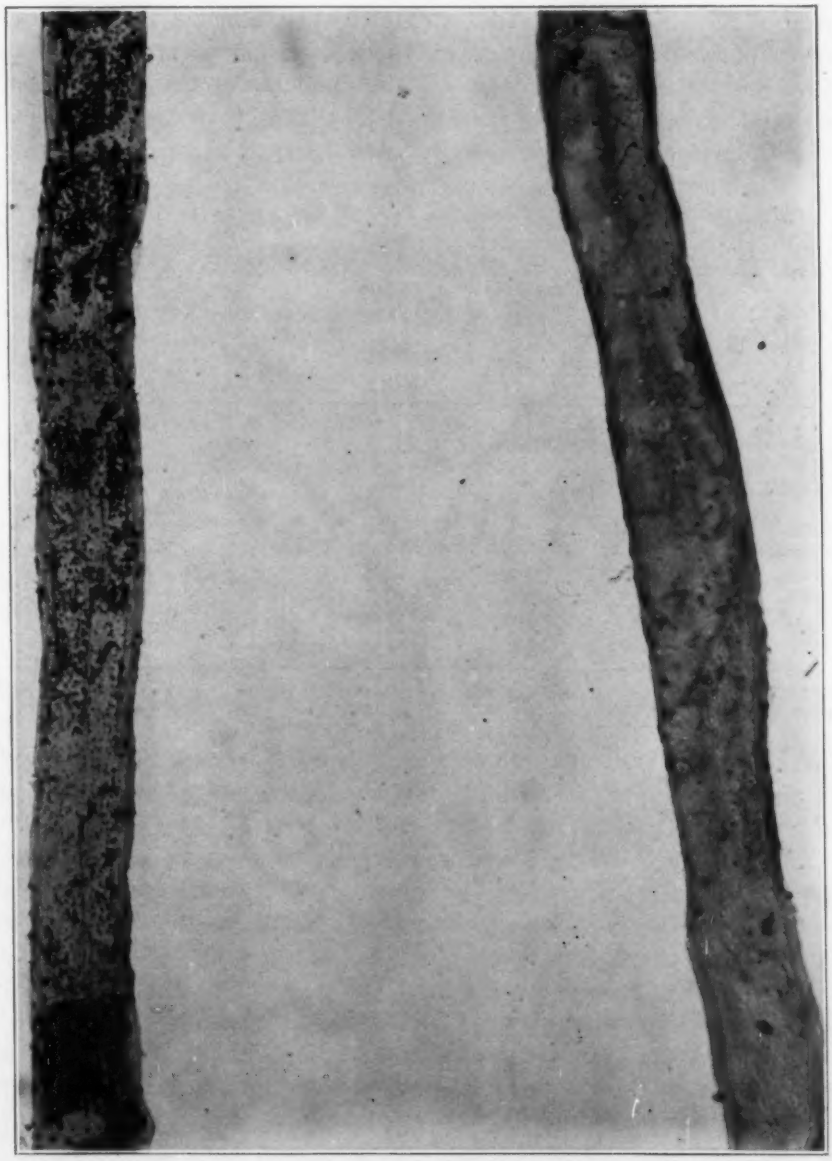

Fig. 2.—Photomicrograph of cellulose fibers from cellucotton. The single fiber on the left has been exposed to bacterial suspension and washed three times. The fiber at the right is a control. It is an untreated, fresh fiber.

air could be passed through a cellulose filter, the personnel being masked with these bacterial absorbent materials. As a safeguard for dissemination by air of oral and nasal bacterial flora from unmasked observers and visitors, radiant energy might be used to destroy the residual bacteria in the atmosphere. It seems to us a sounder procedure to prevent contamination of air and to control as well as to restrict the distribution of bacteria in the atmosphere of the operating room by bacteriologic filtration than to allow gross pollution to occur and depend on radiant energy to make the air safe for all concerned. Bactericidal radiant energy has its uses, but like chlorination of water or pasteuriza-

TABLE 1.—*Effect of the Number of Plies of Cellucotton on Its Efficiency as a Filter* *

Room air control	182 colonies
2 ply cellucotton	6 colonies
3 ply cellucotton	4 colonies
4 ply cellucotton	3 colonies
5 ply cellucotton	1 colony (spreader)
6 ply cellucotton	0

* The number of bacteria are expressed per 10 cubic feet of air. An average of 38 experiments was performed with each type of filter.

TABLE 2.—*Influence of the Number of Plies of Cotton Gauze on the Efficiency of the Bacterial Filter* *

Room air control	164 colonies
2 ply gauze	31 colonies
4 ply gauze	24 colonies
6 ply gauze	15 colonies
8 ply gauze	9 colonies

* The number of bacteria are expressed per 10 cubic feet of air. An average of 16 experiments was performed with each type of filter.

tion of milk it is most useful when employed in conjunction with and in augmentation of other standard sanitary procedures for purification of air.

We attached a large glass funnel to the intake tube of the Wells air centrifuge. Our experiments were divided into two parts, the studies in filtration of air and the application of these results to the improvement of surgical masks.

In all, 94 experiments were conducted in the air filtration studies. The principle was to cover the 6 inch (15 cm.) funnel at the intake of the Wells air centrifuge with the material to be tested. We were able to seal the funnel so that all of the air passed through the filter. Face masks cannot be controlled in this manner. There is always leakage around the masks, usually above.

Table 1 gives the results of the use of cellucotton filters for the air going into the air centrifuge. Table 2 gives the results obtained when gauze filters were used in the same way. The cotton gauze offers

greater resistance to the passage of air, but in this experiment the air had to filter through the cellucotton or gauze. The suction of the machine and the tightly fitting layers of the material forced the air to pass through the filters. When gauze is used for a face mask the escape of the expired air above the mask is more noticeable than when cellucotton is used. The line of least resistance is upward on each side of the nose when four or more thicknesses of gauze are used for a face mask.

We have not found a method of testing the efficiency of masks to remove bacteria from the expired air. We have determined the average bacterial count per unit volume of air in the room. The masked person talked while his face was directly in front of the large glass funnel attached to the intake part of the air centrifuge. Room air naturally

TABLE 3.—*Bacterial Counts per Ten Cubic Feet of Air* *

Room air control	295
Without mask	720
8 ply ordinary gauze mask	572
4 ply cellucotton mask	259

* An average of 10 experiments was performed with each type of filter.

TABLE 4.—*Bacteria per Ten Cubic Feet of Air* *

Control room air	185
6 ply gauze mask	1,362
6 ply cellucotton mask (no B. prodigiosus recovered)	210

* In this experiment the subject's mouth was rinsed (gargle) with a 1:100 dilution of a culture of B. prodigiosus in saline solution before he talked into the machine. An average of 7 experiments was performed with each type of filter.

came into the opening around the head of the masked subject. This experiment was not what was desired, but it was a great improvement over the old method of using opened Petri dishes of agar to determine the air flora.

Table 3 indicates the average results of 40 experiments. The duration of each experiment varied, but the average was twelve minutes. Plain nutrient agar was the medium used in all instances. Talking into the apparatus was carried out in all experiments except the room air control series. The masked subject would read rapidly in a loud tone. Table 3 gives the results obtained without a mask, with an 8 ply gauze mask from the surgical department and with a 4 ply cellucotton mask. We consider that part of the high bacterial count obtained when the thick gauze mask was used was due to the deflection of the expired air around the mask because of the resistance produced by its thickness. The 4 ply cellucotton mask offers little resistance to the expired air.

Table 4 shows a comparison between a 6 ply gauze mask and a 6 ply cellucotton mask. The cellucotton mask was made by placing 6 plies of this material between two layers of thin, wide-meshed gauze. The

TABLE 5.—*Number of Bacteria Passing Through Filter* *

First two minutes	20
Second two minutes	110
Third two minutes	340
Fourth two minutes	275
Fifth two minutes	317
Total	1,062

* The ten minute period of talking was subdivided into five two minute periods. A fresh culture cylinder was inserted at the end of each two minute period. The mouth of the subject was rinsed with a 1:100 dilution of a culture of B. prodigiosus before the experiment. A 6 ply gauze mask was borrowed from the operating room for this experiment.

TABLE 6.—*Bacterial Count per Ten Cubic Feet of Air* *

Control room air sample	170
No mask used	887
Hood type mask with 6 ply cellucotton filter (no B. prodigiosus recovered)	178
Hood type mask with 6 ply cellucotton filter; mask too large, poorly fitted; air escaped above (120 B. prodigiosus recovered)	360

* In this series of experiments the subject's mouth was rinsed with a 1:100 dilution of a culture of B. prodigiosus in saline solution before he talked into the machine. An average of 4 experiments was performed with each type of filter.

TABLE 7.—*Typical Laboratory Protocol*

Purpose	Cubic Feet of Air per Minute	Time Begun	Time Ended	Incubated	Results
Room control	0.75	9:44	9:54	24 hr.	113 colonies
Room control	0.83	10:06	10:16	24 hr.	164 colonies
Room control	0.90	11:00	11:10	24 hr.	191 colonies
6 ply cellucotton	0.785	10:45	10:55	48 hr.	No growth
6 ply cellucotton	0.875	10:20	10:30	48 hr.	1 colony (spreader)
6 ply cellucotton	0.875	10:57	11:07	48 hr.	No growth
4 ply cellucotton with 2 ply moistened cellucotton between	0.875	11:15	11:25	48 hr.	No growth
4 ply cellucotton with 2 ply moistened cellucotton between	0.785	2:16	2:26	48 hr.	No growth
4 ply cellucotton with 2 ply moistened cellucotton between	0.830	2:31	2:41	48 hr.	No growth
4 ply cellucotton with 2 ply moistened cellucotton between	0.875	2:51	3:01	48 hr.	1 colony (spreader)

subject in this experiment rinsed the mouth with a diluted culture of Bacillus prodigiosus. This bacterium seldom occurred in control samples of the room air and then only in one or two isolated colonies. We wished to separate the air in the room from the expired air and thought this method would be helpful.

We expected the cotton textiles to be less absorbent for bacteria when they became saturated with water. Table 5 gives the results of

an experiment tending to bear this out. The time was divided into five two minute periods. The same mask was worn for the whole experiment; the cylinder, coated inside with agar, was changed at the end of each two minute period. The subject's mouth was rinsed with a diluted culture of B. prodigiosus before the experiment began. It is apparent from table 5 that the permeability of the mask increased during the course of the experiment. It should be borne in mind that the moistened, even saturated, 6 ply gauze mask increases the resistance to passage of the expired air and causes more deflection than does a dry gauze mask.

Table 6 illustrates the influence of proper fitting of the face mask on its efficiency as a filter for expired bacteria. The hood type of mask was used in this experiment. A pocket 6 by 4 inches (15 by 10 cm.) was formed in the mask over the nasal and oral orifices, and 6 ply cellucotton filler was inserted in this pocket. The first mask experiments in table 6 illustrate the results with a head mask properly and tightly fitted to the face of the subject. The next series was performed with a hood mask too large for the subject; it fitted loosely and allowed ready escape of expired air by deflection without filtration.

Table 7 gives the laboratory protocol for one day's experiment. This particular experiment was designed to determine the differences between dry and moist 6 ply cellucotton filters. The material was placed over the funnel connected to the intake of the Wells air centrifuge, and the machine was run for ten minutes. The variations in the bacterial flora of the air are shown in this experiment.

COMMENT

Cellulose wadding of the type used in these experiments can be adapted to filtering bacteria from the air as the air passes through the material. This material is more effective than the cotton gauze generally used in surgical masks. The greatest source of oral bacterial flora in our experiments was escape or deflection of the expelled air during loud talking, above the mask lateral to and on each side of the nose. Our primary problem was one of filtering bacteria from the air. We have done some work with various types and new modifications of face masks. These experiments have not been completed. We are testing various types of mask at this time. A disposable, tightly fitting face mask is now being developed and is already in experimental use. A further report will be made on this subject when we are satisfied that we have something practical, useful and efficient.

Covering of the nose and mouth with an impermeable material deflects the expired air all around the edges of the mask, and the atmospheric pollution is the same as if no mask were worn. We

consider that the problem is one of prevention of atmospheric pollution by filtration, similar to removal of bacterial pollution from water by filtration methods. The droplets in the air, seeded with the bacterial flora of the upper respiratory tract, will find their way downward by gravitation and may be a source of infection. The air currents produced by movements of the persons in the room in opening and closing doors will reduce the effectiveness of the impermeable deflection type of mask to almost zero.

We feel that our experiments show the effectiveness of cellucotton as an air filter. The next problem is to prevent air containing bacterial flora of the upper part of the respiratory tract from leaking around the edges of the mask. We are convinced that if all the expired air can be forced through the cellulose wadding filter the bacteria will remain on the cellulose fibers.

SOLITARY XANTHOMA (LIPOID GRANULOMATOSIS) OF BONE

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AND
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Xanthomatous bone tumor, isolated or multiple, occurring in the absence of the Schüller-Christian syndrome is rare. Recognition of this unusual lesion has proceeded apace with delineation of the Schüller-Christian syndrome.

Bony tumors such as those described by Zeyland and Dega and by Krogius, which seem to be classic examples of giant cell tumor with secondary lipoid deposition, bear no resemblance to the type of tumor here described.

REPORT OF A CASE

An Italian boy aged 12 noticed pain and swelling of the left tibial tuberosity five or six weeks before he was first examined, on Oct. 26, 1936. The boy had always been physically active. He remembered no severe injury to his leg or knee, but he had bumped his knee a week previously, while playing football. He had sharp pain on direct pressure over the tibial tuberosity. There was no pain in the left thigh. A diagnosis of Osgood-Schlatter disease (apophysitis) of the left tibial tuberosity was made because of the swelling of the tuberosity and its tenderness to pressure. A roentgenogram, which fortunately included the lower third of the femur, revealed an area of rarefaction at the junction of the lower and the middle third of the femur, suggestive of a bone cyst. It was because of this clinically quiescent lesion of the femur that he was referred by Dr. M. Roth, of Astoria, Long Island.

A bony swelling was palpated on the mesial aspect of the femur, about 2 inches (5 cm.) above the superior border of the patella. This swelling was fixed and slightly tender. It was slightly irregular on its surface and projected a little above the line of the medial femoral cortex. Its base was broad and was a part of the femoral shaft. A cordlike structure ran over its surface. There was no heat of the overlying soft tissues or redness of the skin. General examination gave negative results.

Another roentgenogram of the left femur (fig. 1) showed a roughly ovoid area of rarefaction the size of a silver quarter on the inner side of the bone, at the junction of its middle and lower thirds. The medial cortex was thinned; it bulged slightly at the site of the lesion but was not broken through. Extending proximally from the main lesion, a few smaller, "daughter" areas of rarefaction were seen. The borders of the rarefied areas were lined by sclerotic bone, especially at the lateral part of the main cystic lesion. The lesion was at least one-half the width of the diameter of the shaft of the femur. The larger cyst contained many irregularly placed bony trabeculae which subdivided the lesion into smaller parts. No periosteal reaction or invasion of the soft tissues was noticed.

The lesion seemed benign both clinically and roentgenologically. It was a rarefying lesion of bone with no tendency to bone production. It was peculiar in two respects, its location and its capacity to form daughter lesions. Its location was not typical of bone cyst or of giant cell tumor. It seemed to be an unusual type of benign bone lesion.

On November 2 the tumor was resected (by Dr. Burman). The medial aspect of the femur was approached by a 7 inch longitudinal incision placed anteromedially, the site of tumor being at the center of the incision. The bone was exposed by incision between the vastus medialis and the rectus femoris muscle. The quadriceps bursa was not opened. The periosteum was normal and stripped easily.

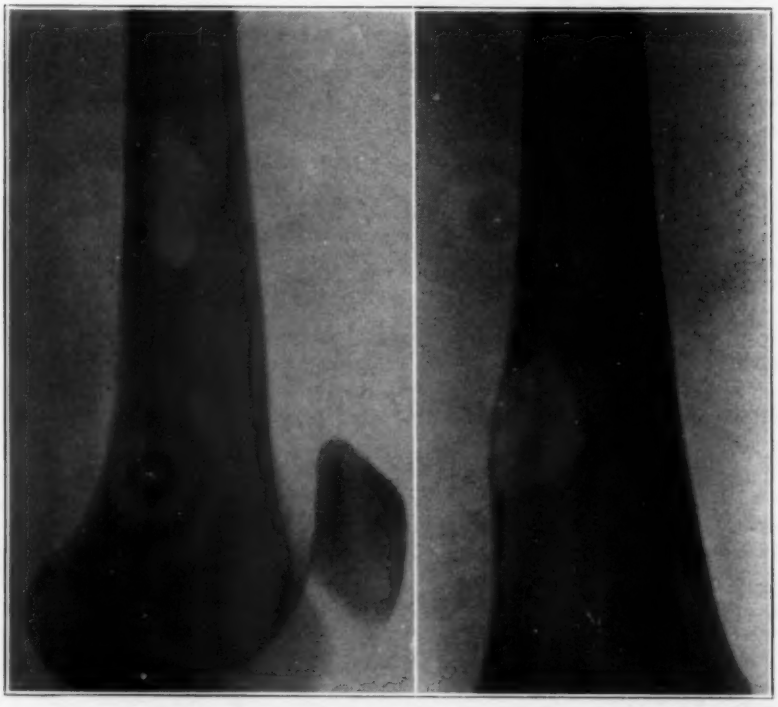

Fig. 1.—Preoperative roentgenogram, taken Oct. 28, 1936, of the xanthomatous femur.

The surface of the bone (which was steel blue) at the level of the tumor was slightly knobby. The tumor was completely resected, the borders of the lesion being carefully measured out with a ruler. The marrow was curetted thoroughly. Total resection of the tumor was verified by a roentgenogram taken immediately, in the operating room (fig. 2).

The gross specimen (fig. 3) consisted of a portion of the shaft of the femur, measuring 2½ inches (6.2 cm.) in length and a little more than one-half the width of the shaft. The medial cortex was thinned and expanded. The medullary cavity was filled with discrete areas of brownish and yellowish tumor tissue. Each yellowish mass was surrounded by a dense capsule of bone, and the intervening regions were also occupied by bone, which was dense and spongy. The largest mass

Fig. 2.—Roentgenogram taken in the operating room after resection of the lesion (Nov. 2, 1936).

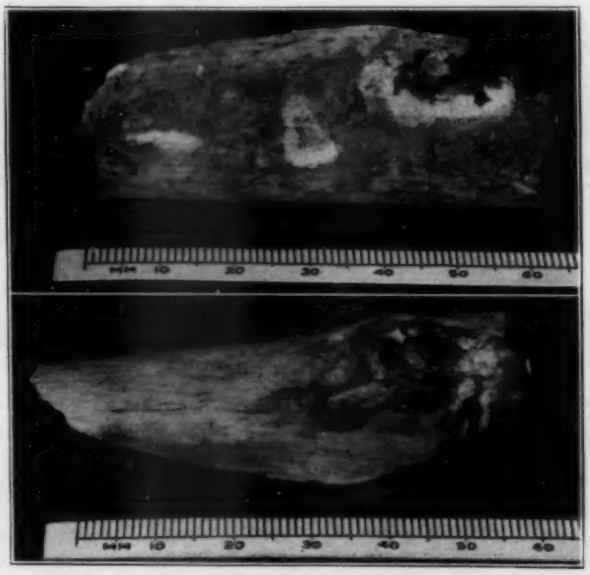

Fig. 3.—Gross specimen. The breaking through of the cortex is a postoperative artefact.

measured ¾ by 1 inch (2 by 2.5 cm.) and corresponded to the expanded portion of the cortex. A microscopic diagnosis of lipoid granulomatosis (xanthoma) of bone was made by Dr. Henry Jaffe, pathologist of the Hospital for Joint Diseases. Sections both of bone and of soft tissue showed the presence of lipoid-containing cells aggregated in masses. (These cells probably contained cholesterol ester.)

Fig. 4.—Microscopic picture of a section of resected bone, showing the presence of foam cells.

The larger masses showed giant cells and were associated with a fibrous tissue reaction. Leukocytes were present in such masses. The larger masses were more fibrotic and eroded the cortex.

Roentgenograms of the pelvis, the skull, the ribs and the right femur were taken later, with negative results. The cholesterol content of the blood, with the

patient fasting, was elevated to 224 mg. per hundred cubic centimeters. (The normal value is 150 to 190 mg.)

The leg was immobilized in a hip spica for eight weeks and in a long leg cast for four additional weeks. The postoperative course was uneventful, and the wound

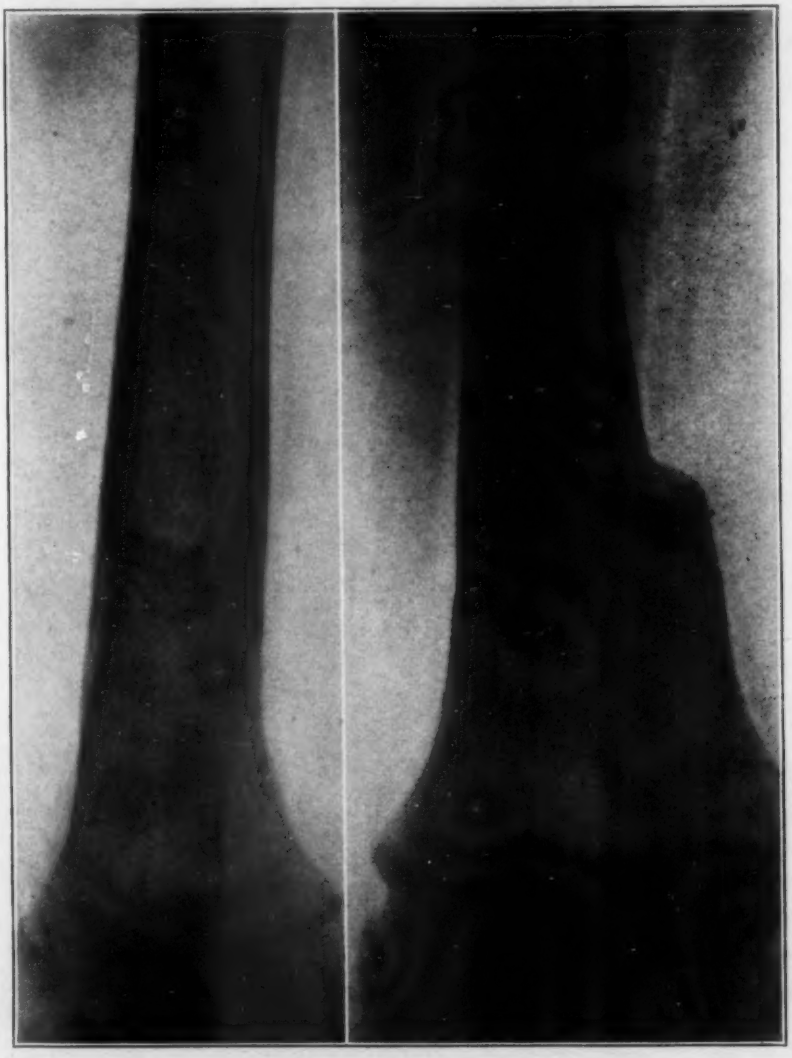

Fig. 5.—Roentgenogram taken Jan. 30, 1937, showing no recurrence of the lesion. Note the progressive filling in of the operative defect of the femur.

healed by primary intention. The disease of the left tibial tuberosity healed spontaneously during the period of immobilization.

The knee could be flexed only from 180 to 170 degrees when the cast was removed, but after administration of physical therapy flexion became complete.

Inability to flex the knee was due to adherence of the quadriceps muscle to scar tissue at the site of operation. At the time of writing this condition has largely been overcome, and the muscle is soft and flexible.

Periodic check roentgenograms showed no recurrence of the lesion to March 1937 (fig. 4). A roentgenogram taken June 19 (fig. 5) showed recurrence of the tumor. At a point just external to the operative site were three small cyst-like areas. Periostitis was present.

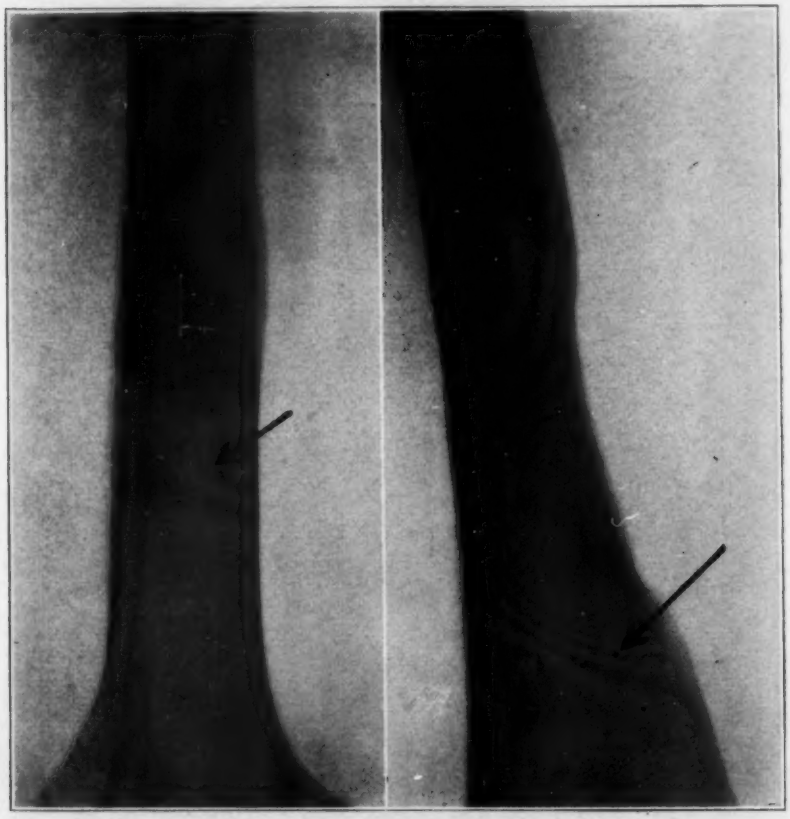

Fig. 6.—Roentgenogram taken June 19, 1937, showing recurrence of the lesion. This is manifested by three round areas of rarefaction, indicated by the arrows. They are better seen in the lateral view. The recurrence is just at the distal part of the resected area.

The patient was given a diet low in cholesterol, and roentgen therapy was begun. The last roentgenogram (fig. 6) showed extensive new bone deposition at the site of the recurrent lesion, which was no longer visible. Two fields, anterior and posterior (10 by 10 cm.), were each given 600 roentgen units at 140 and 150 kilovolts, with filtration of 0.5 mm. of copper plus 1 mm. of aluminum or of 4 mm. of aluminum, at a distance of 40 cm. Six treatments were given, the first three at intervals of one week and the last three at intervals of one month.

The cholesterol content of the blood on June 5 was 200 mg. per hundred cubic centimeters. The patient was last examined on Feb. 11, 1938. His general health was excellent, and he presented no increased urinary output, no prominence of the eyes and no palpable tumors of the skull.

Isolated xanthomatous change of bone is rare. It is likely that multiple osseous involvement, not gross enough to be detected by

Fig. 7.—Last roentgenogram, taken Jan. 11, 1938, showing complete healing of the recurrent lesion. There is bony sclerosis at the site of resection.

roentgenogram, may exist in such so-called isolated xanthomatous tumors of bone. This may have been true in the case presented. New bony foci may later be recognized, and this can be determined only by a periodic and thorough roentgenographic search of the entire skeleton, especially of bones which are favored by the disease. Multiple bony foci of xanthoma have been described in the absence of the Schüller-

Christian syndrome. The latter frequently demonstrates skeletal changes, the most consistent of which (100 per cent) is the change in the skull. Whether there is an ultimate association of the isolated or multiple bony xanthomas here described with the Schüller-Christian syndrome is not answered affirmatively by a study of the reported cases. It is unlikely that such will be the sequence of events in most cases, by reason of age incidence. The age peak of the Schüller-Christian syndrome is usually reached in childhood; isolated or multiple xanthomatosis of bone occurs more often in the third, fourth and fifth decades.

Geschickter and Copeland in a study of 17 cases of Schüller-Christian disease noted that in 2 cases the symptoms of onset were related to solitary lesions in the tibia or the fibula. They described a tumor primary in the fibula, which was seen in 1925. However, a small defect in the skull was noted. In 1934 the patient had multiple skeletal involvement.

ISOLATED FORM

An isolated xanthomatous bone tumor has been described as occurring in a girl aged 12. Our patient was a boy aged 12. The other patients were adults whose ages ranged from 26 to 55.

The disease shows no predilection for either sex. Three patients were males, and 3 were females.

There is no set point from which the disease can be said to begin. Its discovery may be incidental to roentgenographic examination of an adjacent part of the body, investigated for some other cause. This was so in our case, in Phélip's case and in Bahl's case. An approximate length of time, measured by a known injury, would seem to indicate the duration of disease to be from two to twenty-six years, the average being two or three years. A man of 55, with a lesion assumed to be of twenty-six years' duration, noted a mass on the outer side of the upper part of the thigh twenty-six years before. This terminated in an abscess, which maintained itself for fourteen years. Its similarity to a second abscess, of a year's duration, seemed to support this claim.

In 3 cases no trauma was noted. In the remaining cases the trauma was mild, either to the part later affected or to an adjacent part. In no instance was there a single severe sharp or blunt injury to the part. In 1 case there was no remembered history of trauma.

All the patients were in excellent general health.

The patient may have no symptoms. Pain is never severe; it may be absent or it may be intermittent. No redness or heat is noted over the tumor. Swelling is sometimes seen. In 1 case this swelling broke through the skin and discharged necrotic débris containing cholesterol crystals. In another a blood clot developed after an injury above the site of xanthoma. A chestnut-sized tumor ultimately formed at this point,

which was considered sarcomatous on microscopic examination. There may be some question with regard to this diagnosis, since the patient's health remained excellent for three years in the presence of this recurrent tumor, which had not metastasized.

The femur is most often involved in the isolated form of the disease. (The incidence of femoral involvement in Schüller-Christian disease is 26 per cent, according to Lazarewa. This is third in order of frequency, the incidence of femoral involvement ranking below that of invasion of the skull and the pelvis and being equal to that of involvement of the upper jaw.) The epiphysial ends of the bones are spared. In the lower part of the femur the lesion exists at the junction of the middle and the lower third of the bone. This was true of Phélip's patient, a girl of 12, and in our case. Localization, then, was the same for this age group. The upper third of the femur, including the greater trochanter, was involved in 2 patients, each 55 years of age. The lesser trochanter was spared in both. In 1, the disease stopped at the intertrochanteric line, but in the other the neck of the femur was extensively invaded, with ultimate pathologic fracture of the neck, which led to discovery of the xanthoma. The lower third of the fibula and the upper third of the humerus at its junction with the middle third were sites of election in 2 other cases. The proximal phalanx of the right thumb was involved in the final case. This indicates a predilection for the long bones of the body. In only 1 case was there a demonstrable lesion in any of the flat bones. This lesion was an area of rarefaction in the occiput, said not to be characteristic of Schüller-Christian's syndrome.' It was not demonstrated clinically. There was no evidence of predilection for the right or the left side of the body.

The tumor is firm and bony hard and is an integral part of its bone. It is sometimes slightly sensitive to pressure. When the tumor becomes superficial, as in the thumb, it distends the overlying skin, which may show dilatation of the fine vessels. The surface of the tumor is finely lobulated or smooth. Ordinarily, it may be difficult of palpation because of its depth of location. Its size is variously estimated, as 2 cm. in diameter, as the size of a plum, as the size of a walnut and as the size of an egg. In only 3 cases did it form a readily visible mass. In the lower third of the fibula it formed a soft, elastic egg-shaped mass; in the thumb, a circular tumor 2 cm. in diameter, and in the upper part of the thigh, a mass which discharged necrotic tissue with cholesterol crystals. The adjacent joint usually shows no disturbance in function. In 1 case there was effusion into the knee joint, which apparently was persistent; its exact relation with the femoral lesion was not adequately determined. One patient noted pain in the left hip for two years on exertion, but the function of the hip was not disturbed till the onset of pathologic fracture of the neck of the femur.

ROENTGENOLOGIC PICTURE

The roentgenologic appearance is that of a benign, delimited, confined bone lesion. Its essential character is osseous rarefaction (replacement by xanthomatous tissue) in the shaft of a long bone. It may be expansile and divided into small cysts by thin bony septums. Small daughter cysts may extend out from the main lesion. Such secondary cysts are irregularly oval and may be longitudinally placed. A fairly thick area of limiting bone sclerosis is noted about each lesion. The cortex adjacent to the lesion may be considerably thinned and even perforated as the result of pathologic fracture. There is no calcification, and no mass in the soft tissues is seen. No tendency to bone production or periosteal involvement is present. The epiphysial ends of long bones are not invaded.

DIFFERENTIAL DIAGNOSIS

In the differential diagnosis the first to be considered is the localized form of osteitis fibrosa cystica. In this disease the entire width of the bone is usually involved, and deformities occur. The lesion is relatively stable and does not tend to increase in size as rapidly as does xanthoma. The cystic divisions of xanthoma are more regular and less diffuse. There is less tendency to pathologic fracture in cases of osteitis fibrosa cystica, and there is increased tendency to distortion. Decalcification of the bone in which the lesion is situated is marked. In the presence of xanthoma, on the other hand, the adjacent bone is normal.

Giant cell tumor is also to be considered. Location of the lesion in the shaft of the bone and tendency to smaller and daughter cyst formation with sclerotic borders are in favor of a diagnosis of xanthoma. Giant cell tumor occurs usually in patients between 20 and 30 years of age and is usually located in the epiphysial end of a long bone. Bone cysts as a rule occur in younger patients (up to about 18) and are usually symmetrically placed in the medullary cavity. They are situated in the proximal ends of long bones, commonly in the humerus, the tibia and the femur. The bone cyst stops at the epiphysial line. Occasionally septums may traverse the cyst, but these are usually few and thin.

Enchondroma in the shaft of a long bone is as uncommon as it is common in the phalanges. It also occupies the entire width of the bone.

The rare adamantinoma is also to be considered. Extradental adamantinoma is found in the tibia.

Echinococcus cysts are very rare. Such a lesion has no limiting sclerotic border. A history of the patient's association at some time with dogs or sheep is usually obtained.

One of us has observed several cases of hemangioma of bone (os calcis). This lesion is also expansile, trabeculated and rarefying. We have never seen it in a long bone. It is characteristically radiosensitive. Osteomyelitis is ruled out by lack of bone production and periostitis, by absence of sequestrums and by the clinical picture (fever, abnormal blood count, local tenderness, redness and pain).

Multiple myeloma occurs in patients past the age of 40. It shows rarefied medullary punched-out areas in many bones, with no bone production and no limiting sclerotic border. The Bence Jones test usually gives positive results. The general condition of the patient serves as a point in differential diagnosis, as it does in cases of metastatic malignant tumor (carcinoma, melenoma).

Metastatic malignant tumor may be single or may involve many bones. The single lesion is usually situated at the site of entrance of the nutrient artery. It is usually erosive and expansile. It is not trabeculated, nor is it encircled by sclerotic borders.

Biopsy is the only sure means of diagnosis, and it is pertinent that in no case was the correct diagnosis made preoperatively. Various diagnoses were made: localized osteitis fibrosa cystica, vacuolar osteitis, melanosarcoma and questionable sarcoma. Some authors made no definite preoperative diagnosis. The procedures used were resection of the tumor in 3 cases when this was possible, curettage of the tumor in 2 cases (the upper end of the femur and the neck of the femur) and guttering of the femur in 1 case, with insertion of fat and a pedicled muscle graft obtained from the quadriceps muscle. The lesion in 1 case was not externally visible when the bone was exposed, and drill holes made through the cortex localized the tumor.

In no case at operation was the periosteum found to be altered. The tumor was usually outlined by sclerotic bone and subdivided into many parts of finer bony septums, between which was a friable, soft tissue, ranging in color from sulfur yellow to chocolate brown. The cortex was sometimes thinned and expanded and in our case was steel blue. In Fürst's case there was invasion of the muscle and skin by the cholesterol-containing tissue, which contained much fatty stuff, resembling, it was said, the material found in cholesteatoma. A necrotic abscess was present. A large number of faceted, pure cholesterol stones were found.

The postoperative course was uneventful in all instances, except in Schrank's case, in which he thought death of the patient imminent. All wounds healed well. The follow-up period is given in only 2 cases. Schrank's patient was observed for eight months. The hip was stiff, and the patient walked well. Consolidation of the rarefied area in the femoral neck was present after curettage. Vermooten's patient was

followed only two months. At the time of writing it is understood that in the remaining cases, although no exact period of follow-up is noted, the patients are in good general health and the diseased area in bone has not increased in size. No note is made of further osseous involvement. No patient has apparently presented any signs of the Schüller-Christian syndrome.

After the nature of the lesion was detected by microscopic examination of the excised tissue, tests to determine the cholesterol content of the blood were done in 3 cases. The cholesterol value in 1 case was 212 mg. per hundred cubic centimeters of blood, a definite elevation above normal. In the remaining 2 cases both free cholesterol and cholesterol esters were estimated. In 1 case the value for free cholesterol was 70 mg., that for cholesterol esters 103 mg. and that for total cholesterol 173 mg. per hundred cubic centimeters. In the final case the value for free cholesterol was 189 mg. per hundred cubic centimeters and that for total cholesterol 231 mg., denoting a definite rise. Bürger's cholesterol feeding test was not done in any case. The value of this test will be commented on later.

Schrank noted that a son of his patient, a boy aged 7½ years, had an area of rarefaction in the right eighth rib. The roentgenologic appearance of this was comparable with the xanthomatous lesion of the left femoral neck of the father. This boy had pleural effusion on the right side, which contained a chylous fluid. He died after an operation for supposed caries of the rib. Postmortem examination was not done.

THE MULTIPLE FORM

The multiple form of skeletal xanthomatosis is as rare as the isolated form. Six cases have been reported. In 4 of these the diagnosis was verified by microscopic examination of tissue, and in 2 (Kienböck and Selda; Kienböck and Schnek) the diagnosis was roentgenographic, based on the previous experience of Kienböck in another case of multiple osseous involvement, in which diagnosis was ultimately made by biopsy. That this experience in repetition is invaluable is proved by the case of Snapper and Parisel, who made the correct diagnosis in their case after publication of the report of Kienböck and Meworach.

The usual working diagnosis has been generalized osteitis fibrosa cystica, and so confident have two of the investigators been of this (Snapper and Parisel; Kienböck and Schnek) that parathyroid exploration was carried out (twice in Snapper and Parisel's case), with completely negative results.

While there are multiple osseous invasions in this form of xanthomatosis, it is usually not as widespread, either generally or locally, as is that of generalized osteitis fibrosa cystica. The smallest number of bones

involved was two and the largest ten, not counting the involvement of phalanges of hands and feet in that case. The usual number of bones involved was two to five. The skull was normal in all instances. The long, tubular bones were again favored, especially the upper part of the femur, its greater trochanter and part of the femoral neck. The humerus was next in frequency, the radius, the ulna, the fibula, the phalanges of the feet and the hands and the metatarsal bones being also affected. Of the flat bones, the left ilium was once involved; invasion of a single rib was seen in 2 cases, and an invasion of three vertebral bodies was noted in 1 of the cases in which a rib was affected. The flat bones were affected in only 2 of the 6 cases. The femur was altered in 5 of the 6 cases and the ulna and fibula in 2 cases.

Complete studies are necessary to differentiate multiple xanthomatosis from osteitis fibrosa cystica generalisata (von Recklinghausen's disease). Roentgenologically, as with the localized form of osteitis fibrosa cystica, the bones are malacic and deformed. The areas involved are more extensive. The trabeculae are coarser and thicker and the cystic areas larger and more irregular. More bones are involved in von Recklinghausen's disease, and the disease is more diffuse. There is more tendency to cyst fusion and involvement of the epiphysial ends of long bones. Determination of the calcium content, the phosphorus content and the phosphatase content of the blood is important. Cholesterol studies are helpful in cases of xanthoma.

Multiple myeloma and metastatic malignant tumor must also be considered. These have been previously discussed. In the presence of osteoclastic metastatic malignant tumor, the lesions are purely erosive and perhaps slightly expansile. Bony septums traversing the lesions are not seen. There are no restraining influences. The osteoblastic variety of metastatic malignant tumor need not be considered in differential diagnosis, since it gives rise to osteosclerosis.

There is a rare multiple cystic disease of bone which should be mentioned. It occurs in young persons (up to the age of 20 or 21). It is unilateral. Microscopically the lesion shows fibrous replacement of the bone marrow. Dr. Henry Jaffe has termed it "polyostitic fibrous dysplasia."

The age and sex incidence is similar to that of the isolated form. There were 4 female and 2 male patients. One girl was 10 and 1 boy was 14 at the time of his admission to the hospital. There were 3 patients in the third decade of life, and the oldest was a man of 40.

Trauma plays no great part. A history of competent trauma was not usually given. A boy aged 14 fell 6 feet (1.8 meters) from a hay loft, fracturing the neck of the left femur, through an area of xanthomatous invasion. A slight slip caused pathologic fracture of the surgical neck of the right humerus in another case.

The duration of the disease is again questionable and, as far as it can be determined, it is from two to five years. Study of a patient over a period of years indicates a remarkable stability of the existing lesions, with slight tendency to formation of new lesions. In Kienböck and Meworach's case the development of a visible node on a rib was observed in the course of the disease; in Shelling and Voshell's case the left ilium showed later involvement roentgenographically. Clinically, in this case, several bones later revealed painful thickening of their shafts. Three patients were studied from two to five years.

The disease may be asymptomatic, as in the 2 cases of Chester, in which multiple osseous involvement was observed at autopsy.

Pathologic fracture is more frequent in the multiple form of skeletal xanthomatosis. This depends on the simple mathematical fact of greater probability. The neck of the femur was affected in 2 cases and the surgical neck of the humerus in 1. There may be recurrence of pathologic fracture, and in Snapper and Parisel's case 6 such recurrences were noted. In Kienböck and Schnek's case, two pathologic fractures were noted at the surgical neck of the humerus, and a pathologic subperiosteal greenstick fracture was suspected in point of time between the two evident fractures. The femoral neck united in coxa vara. In Snapper and Parisel's case there were deformity of both femoral shafts and shortening of one lower extremity as compared with the other. In Shelling and Voshell's case there was a coxa vara deformity of the left hip with shortening of the left lower extremity of 3.5 cm. Healing was delayed in Kienböck and Schnek's case, and pseudarthrosis developed after the last pathologic fracture.

Multiple xanthomatous lesions of the skin were present in Merrill's case.

Chemical studies were made in 3 cases. A high value, of 322 mg. of cholesterol per hundred cubic centimeters of blood, was found in Snapper and Parisel's case on one occasion, but on other determinations the content was not above normal. In Shelling and Voshell's case there was an increase of cholesterol in the blood to 221 mg., and in Kienböck and Schnek's case the value was 140 mg. Bürger's test was carried out twice (Snapper and Parisel, Kienböck and Schnek). This test is not reliable or specific of change in cholesterol metabolism. Five grams of cholesterol is dissolved in 50 to 100 Gm. of olive oil and given to the fasting patient. The cholesterol content of the serum should reach a level twice as high four hours later, according to Bürger. Bürger's test gave negative results in both cases, and there was no hypercholesteremia. The value for cholesterol ester is increased over that for free cholesterol in the presence of the Schüller-Christian syndrome, even to five times. Usually 60 to 70 per cent of the total cholesterol is cholesterol

ester. In Snapper and Parisel's case, it was 80 per cent. The calcium content of the blood was 12.6 mg. per hundred cubic centimeters in 1 case and normal (no figures given) in another. In 1 case, in which parathyroid exploration was done at the same operative session when thyroidectomy was done for goiter, the calcium content of the blood was not mentioned. In Shelling and Voshell's case the urinary excretion of calcium was normal, and the value for phosphatase was 8.4 units per hundred cubic centimeters.

We are not including a study of the skeletal changes associated with the Schüller-Christian syndrome or of those atypical forms of this syndrome in which occasional flat or long bones are involved, as in Anspach's case. The Schüller-Christian syndrome may demonstrate all or part of its triad of symptoms—exophthalmos, diabetes insipidus and changes in the skull in association with one or more skeletal xanthomatous lesions. Lazarewa's study is an excellent one for reference.

THERAPY

For the isolated forms of the disease, effective therapy consists of resection of the tumor (when possible) or curettage. When it is possible to establish the diagnosis without biopsy, roentgen therapy, as advocated by Sosman, is the treatment of choice. It is, indeed, definitely indicated for the multiple form of the disease once diagnosis has been made. Ultraviolet irradiation therapy was used by Shelling and Voshell, and the disease was brought to a standstill. A diet low in cholesterol should be tried, especially in cases of multiple skeletal xanthomatosis with hypercholesteremia.

The ultimate fate of the patient is not indicated in any of these case reports. There were no fatalities, but no patient can be said to be definitely cured. The disease is relatively stationary, but new bone foci may develop, since the illness is a generalized metabolic disease. The isolated lesion is, then, only fortuitous or apparent. Function is disturbed in the not infrequent presence of pathologic fracture, and healing may be delayed or deformity may develop.

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SIXTY-SEVENTH REPORT OF PROGRESS IN ORTHOPEDIC SURGERY

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HEREDITARY AND DEVELOPMENTAL DEFORMITIES

Chondrodystrophy with Flattening of the Vertebrae.—Guerin and Lachapele [1] report a case of chondrodystrophy, the patient being a boy aged 7. They label the condition in this case "platybrachyspondylie," since the vertebrae, particularly in the lower portion of the dorsal region, were large and flat, each tending to end anteriorly in a pointed extremity. This resulted in moderate dorsal kyphosis. Associated abnormalities of the skeleton in other regions were also found. In both feet there was a tendency to hallux valgus. The first metatarsal bone was large and short, with a large epiphysis. The second, third and fourth metatarsal bones were curved medially. In place of the scaphoid and the first cuneiform bone there were several ill defined centers of ossification and the second and the third cuneiform bone were fused. Both hips exhibited coxa vara deformity. There was general retardation in the development of most of the skeletal epiphyses. In reviewing the literature the authors found reports of 22 similar cases, with slight variations in the associated skeletal abnormalities. The authors feel that in cases of chondrodystrophy of the spine other skeletal defects would be found more often if roentgenograms of the remainder of the skeleton were taken routinely.

This report of progress is based on a review of 141 articles selected from 225 titles relating to orthopedic surgery and appearing in the medical literature approximately between March 1 and July 1, 1938.

1. Guerin, R., and Lachapele, A. P.: Rev. d'orthop. **25**:23, 1938.

Chondrodystrophy.—Sargent [2] had the opportunity to study 10 adults suffering from chondrodystrophia foetalis, 3 females and 7 males. The author believes that only the milder forms of this disease permit the patient to reach adult life. The disease appears to be transmitted by males. Roentgenologic and serologic studies showed no other disease in these patients.

Atypical Chondrodystrophy.—Marquardt [3] describes 7 cases of growth disturbance. The first 3 are typical cases of chondrodysplasia. The second group consists of the cases of 2 sisters. One of these cases is typical. The case of the other sister is only suggestive of the lesion, presenting multiple mild epiphysial disturbances. The third group consists of 2 cases in which there were multiple abnormalities of cartilaginous growth. The author, on the basis of roentgen findings in the pelves, the vertebrae and the knees similar to those seen in cases of chondrodysplasia, suggests that these are atypical cases and that many fleeting transitional types of such disturbance probably exist.

Infantile Kyphosis.—Frejka [4] points out that dorsal kyphosis is not uncommon in children between the ages of 4 and 14 and that there is a definite relation between kyphosis and nasal obstruction. About 80 per cent of a group of children with nasal obstruction due to adenoids showed some degree of increased dorsal kyphosis. Nasal obstruction by adenoid tissue or by chronic mucosal hypertrophy necessitates mouth breathing, and this superficial breathing is accomplished by means of the diaphragm, the abdominal muscles and the lower part of the thorax. The upper part of the thorax is not used and remains in the position of expiration. This results in the thoracic vertebral column remaining in the position of expiration, curved forward to form an arc at the back. As the child grows the curve becomes more pronounced and more rigid. Treatment consists first in removal of the nasal obstruction and subsequently in training directed toward breathing through the nose and with the thoracic cage. Good results are obtained if treatment is undertaken before the curve becomes rigid.

[ED. NOTE.—A similar deformity has been observed in children suffering from asthma.]

TUBERCULOSIS

Treatment of Tuberculosis of the Foot.—Calve [5] states that tuberculous infection accentuates the anatomic differences between the foot of an adult and that of a child. In a small child the great amount of cartilage surrounding the bony muscles of the tarsal bone preserves the

2. Sargent, W. S.: U. S. Nav. M. Bull. **36**:67, 1938.
3. Marquardt, W.: Arch. f. orthop. u. Unfall-Chir. **38**:711, 1938.
4. Frejka, B.: Rev. d'orthop. **25**:110, 1938.
5. Calve, J.: Bull. Soc. belge d'orthop. **10**:175, 1938.

form of the bone and protects the articulations from infection. In a child with tuberculosis of the foot, healing may occur or a fistula may develop. A minimum of two years is required for healing. During this period there should be complete immobilization and no attempt at standing. If healing is long delayed in a case of tibiotarsal infection, one may perform an astragalectomy. If secondary infection has occurred, adequate drainage is the first requirement. Astragalectomy is advised for drainage in the posterior part of the foot. For the distal tarsal bones bilateral drainage is advocated, with resection of the bone if necessary. Healing is often surprisingly good. The shape of the foot should be preserved if possible. Amputation should never be performed on children. Constant watch must be kept to prevent severe deformity. In adults, healing occurs in a fair number of cases after prolonged immobilization. When healing does not occur and secondary infection intervenes, amputation of the foot offers the best chance of cure. Resection and astragalectomy should not be performed on adults.

POLIOMYELITIS

Treatment of Acute Poliomyelitis.—Mills [6] gives an account of the so-called "Sister Kenny Treatment." This method of treatment has been used in a "chain" of 1,400 cases in Australia but in only 35 cases in which the condition was in an early stage. In contradistinction to the orthodox methods, comprising rest, immobilization in neutral position, splinting and subsequent massage, the view is taken that the muscular pain results from venous engorgement and consequent anoxemia of the paralyzed vessels and that the limbs must be treated eventually by foments and hydrotherapy to restore capillary tone and by movement through the full range of each joint every two hours. Pain and tenderness always respond to such treatment within three days, and a graded system of reeducation is started, usually within the first week of paralytic manifestations. It is claimed that in no patient treated by this method has deformity developed and that there has been no tropic disturbance, such as chilblains or impairment of growth.

[ED. NOTE.—This technic is now being tried at Queen Mary's Hospital, Carshalton, England, where a ward has been set aside for the purpose. It is doubtful whether it will be long continued when the end results are compared with those following the commonly accepted treatment as reviewed in the last report of progress.]

CHRONIC ARTHRITIS

Gonorrheal Arthritis.—Criteria for diagnosis of gonococcic arthritis are, according to Spink and Keefer: [7] (1) local gonococcic infection

6. Mills, F. H.: Brit. M. J. **1**:168, 1938.
7. Spink, W. W., and Keefer, C. S.: New England J. Med. **218**:453, 1938.

immediately preceding the attack of arthritis or occurring at the same time, (2) smears and cultures of urethral or cervical exudates revealing gonococci, (3) positive reactions to gonococcic complement fixation tests of either the blood serum or the synovial fluid, and (4) gonococci in the aspirated contents of the joints or tendon sheaths. Treatment was instituted in three groups of patients as follows: Group 1 consisted of 26 patients treated by medical means only. Group 2 consisted of 24 patients with effusion into one or more joints, treated with aspiration. Group 3 included 20 patients with purulent articular effusion treated with surgical drainage. Follow-up studies revealed that 20 of the 26 patients in group 1 were free of all articular symptoms and had no limitation of motion; 14 of the 24 patients in group 2 showed no limitation; 3 of the 20 patients in group 3 had complete articular function. Hyperthermia was not used in these cases, and sulfanilamide was not given.

Multiple Hydrarthroses in Chronic Rheumatism.—Ravault and Leger [8] report 2 cases of what they believe to be a distinct form of arthritis, to which they give the name "synovial dropsy." The condition in their cases was characterized by an insidious onset of effusion into the large joints, particularly those of the knees. The effusions were large. In 1 case there was also a collection of fluid in one of the flexor tendon sheaths. The patients suffered little pain. There was no tendency to ankylosis, the only limitation of motion being from the tension of the articular fluid. In 1 case no destruction of the joint surfaces was noted by roentgenograms even after thirteen years. The effusions were characterized by their extreme chronicity and their tendency to recurrence in spite of many different kinds of therapy. In searching for a cause of this peculiar articular disease the authors eliminated gonorrhea, syphilis, tuberculosis and gout. They were unable to assign to it any definite cause.

THE BACK

Lesions of the Intervertebral Disks and Ligamentum Flavum.—Naffziger [9] gives a clear and detailed description of the normal and pathologic anatomy of the intervertebral disks and the ligamentum flavum. The anatomic findings are correlated with symptoms and treatment. The anatomic side of the subject is illustrated with enough clinical data to lend practical interest.

[ED. NOTE.—This is an excellent paper, well illustrated and well worth reading as a foundation for study of any of the recent clinical and statistical studies on these conditions.]

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8. Ravault, P. P., and Leger, G.: Lyon méd. **161**:81, 1938.

9. Naffziger, H. C.; Inman, V., and Saunders, J. B. M.: Surg., Gynec. & Obst. **66**:288, 1938.

Active Braces for Scoliosis.—Wolf [10] reviews the historical development of braces for the correction of scoliosis. The deformities for which correction is sought are: (1) curvature of the spine, (2) overhang of the spine in relation to the pelvis, (3) torsion and hump formation, and (4) diminution in height of the body. Most braces attempt three point pressure, i. e., pressure at both ends and at the apex of the curvature. The force cannot be made to act on the spine itself but must be applied through the ribs. For force to be exerted on the apex of the curve the force must be directed below the apex, since the ribs follow a downward direction. Pressure must also be applied obliquely. Axillary crutches can exert pressure only on the ribs; they cannot lift the shoulder girdle. Lateral displacement of the thorax can be improved by pushing on the same side with a pad against the pelvis or by pulling with a thigh band on the contralateral side. Scoliosis cannot be corrected by braces alone but correction can be continued by such means after the spine has been somewhat mobilized.

OSTEOMYELITIS AND SUPPURATIVE INFECTIONS.

Osteomyelitis Caused by Friedländer's Bacillus.—Septicemia and osteomyelitis caused by Friedländer's bacillus occur most commonly in adults. Talbot and Parlange [11] report 1 case and review 5 others from the medical literature. This type of osteomyelitis is apparently rare and is always serious, death frequently resulting from septicemia; in 3 of the 6 reported cases the patients died. The diagnosis is made from bacteriologic examination. Neither the clinical nor the roentgenologic appearance differs from the usual pathologic picture of osteomyelitis. Treatment is chiefly general and is directed toward relief of symptoms. Drainage is performed only when there is definite abscess formation.

Pyemic Articular Metastases.—Wiesman [12] reports 4 postmortem examinations in which pyemic articular metastases were observed. In 3 cases the sacroiliac joints (among others) were involved, and in 1, suppurative arthritis of the occipitoatlantoid joint and of the atlantoepistrophic joint was observed. In the last-mentioned case cervical symptoms developed three days after a tonsillectomy. Wiesman analyzes the distribution of articular lesions in the protocols of 52 cases of pyemia observed in the pathological institute of the University of Zurich, Switzerland. The knee was by far the most often affected. The other major joints of the extremities were involved less frequently. Symmetric involvement was observed in one fifth of the cases. The infection was mainly streptococcic.

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10. Wolf, J.: Am. J. Surg. **39**:557, 1938.
11. Talbot and Parlange: Rev. de chir., Paris **76**:271, 1938.
12. Wiesman, E.: Deutsche Ztschr. f. Chir. **249**:221, 1938.

Roentgen Diagnosis of Osteomyelitis of the Vertebrae.—McNutt [13] reports in detail 2 cases of osteomyelitis of the vertebrae and includes an excellent review of the literature. In the acute form the disease is associated with high temperature, severe pain, prostration and high mortality. Paralysis is a frequent complication. The chronic form is milder in all its aspects and probably occurs as frequently as the acute form. The disease occurs more frequently in males than in females. Any portion of the vertebral column may be affected, but the most frequent site is the lumbar region, the next in order being the cervical, the dorsal and the sacral region. Early in the disease the roentgenogram may be normal or may show only slight haziness; later the changes may be characteristic of rarefying and proliferating osteitis. Commonly the condition develops as a destructive bone lesion which early shows new bone formation.

Surgical Principles in Treatment of Infections of the Hand.—Koch [14] outlines simple procedures whereby infection may often be prevented after an injury to the hand. If the patient is seen immediately the wound is thoroughly washed with soap and sterile water applied with soft cotton. When this is done infection rarely follows. The wounds are sutured immediately. Infection occurs more often when wounds are not treated for several days. When infection has taken place the first essential is absolute rest. An attempt is made to localize the infection with large, warm, wet sterile dressings. Roentgen treatment of ½ erythema dose, repeated in forty-eight hours, seems to be helpful. Ice packs are contraindicated for an infection of this type. Conservative treatment should be continued until localization of the infection has occurred. For each condition there is one best method of drainage. Operation should be performed with the region under a tourniquet. Rest and warm wet dressings should be continued after drainage has been instituted. If infection is unduly persistent a foreign body, sometimes a necrotic tendon or a bony sequestrum, should be suspected. The removal of the foreign body should be carried out gently. After infection subsides, function should be restored if possible.

Immobilization and Posture in Treatment of Infections of the Extremities.—Wangensteen,[15] writing on acute infections of the extremities, states that "an inch of gravity operating for three days will accomplish as much as three weeks of heat and massage." Accordingly, he advocates rigid immobilization and elevation of the affected member in cases of infection. He prefers using immobilization by a plaster cast with appropriate windows for dressings to other methods of immobilization. He believes that one should strive for physical immobility and elevation, keeping the swelling at a minimum.

13. McNutt, J. R.: Am. J. Roentgenol. **39**:52, 1938.
14. Koch, S. L.: West. J. Surg. **46**:301, 1938.
15. Wangensteen, C. H.: Minnesota Med. **21**:225, 1938.

NEOPLASMS

Primary Adamantinoma of the Tibia.—This tumor, which originates from dental enamel, is of extremely rare occurrence elsewhere than in the jaw. Dunne [16] found only 6 cases in the literature, which he analyzes and discusses. A typical case is reported in detail, with photographs, roentgenograms and photomicrographs. Although diagnosis of this tumor is difficult to make by means of roentgenograms, biopsy of material obtained by aspiration is a safe and valuable procedure. Treatment consists of (1) amputation (if the tumor is extensive as in the case reported), or (2) resection (if the involvement is not great and if no cell pockets are overlooked). Irradiation has proved disappointing except for some tumors of the jaw. The author feels that amputation should provide complete and lasting cure.

Benign Osseous Lesions Showing Invasion of Bone by Spindle Cells.—Murphy [17] reports 4 cases of benign osseous lesions with invasion of bone by spindle cells, in which the lesions were treated with excellent results by means of the roentgen rays. In 3 cases the condition was caused by a low grade infection. In the fourth case the lesion was a giant cell variety of osteitis fibrosa cystica.

Hematologic Diagnosis of Multiple Myeloma.—Zadek [18] has been able to make a diagnosis of multiple myeloma by vital staining of marrow obtained by sternal puncture. He believes that the disease can at times be diagnosed by the finding of lymphoid or plasma cellular reticulum cells with "nuclear granules."

Primary Bone Tumor in Children.—Coley and Peterson [19] discuss the primary tumors of bone observed in children. Primary bone tumors are more frequently malignant in children than in adults. Diagnosis is often difficult. Pain in children is often to be explained on a rheumatic basis. Pain for which no definite cause can be found indicates roentgen examination of the extremity. One should not wait for the development of swelling. A study of the phosphatase, calcium and phosphorus content of the blood is sometimes of value. Biopsy of material obtained by aspiration is sometimes helpful. The common benign tumors are solitary bone cyst, giant cell tumor, chondroma, osteoma and multiple congenital chondrodysplasia. The common malignant tumors are osteogenic sarcoma, endothelioma and liposarcoma. These are best treated by roentgen therapy. Other malignant tumors are usually treated surgically if they are accessible.

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16. Dunne, R. E.: New England J. Med. **218**:634, 1938.
17. Murphy, J. T.: Am. J. Roentgenol. **39**:586, 1938.
18. Zadek, I.: Wien. klin. Wchnschr. **23**:632, 1938.
19. Coley, B. L., and Peterson, R. L.: Am. J. Surg. **39**:334, 1938.

MUSCULAR INJURIES

Rupture of the Biceps Brachii Muscle.—Waugh [20] believes that rupture of the biceps brachii muscle is not uncommon but is often unrecognized. He reports the cases of 14 patients admitted to the United States Marine Hospital in San Francisco and to the New Orleans Hospital and Dispensary for Women and Children. The injury was due to indirect trauma in 7 cases and to direct trauma in 4. In 1 it followed a stabbing injury, and in 2 the cause was uncertain. Among those in which it was caused by indirect trauma, a positive Wassermann reaction was obtained in 3. Rupture of the muscle may occur at any site. The long head of the biceps muscle is most frequently ruptured (12 of the reported cases). Rupture in the bicipital groove is usually the result of degenerative changes. Rupture below the bicipital groove is common in direct trauma. The short head of the biceps muscle was torn in 2 cases. The symptoms and signs were variable. There was always a history of trauma followed by pain, weakness in the arm and discomfort in the shoulder. In the cases reported the most constant sign was a deformity in the contour of the biceps muscle. Twelve of the 14 patients were operated on. Rupture of the long tendon was usually easily repaired. A tear at the myotendinous junction usually required a fascial transplant. For partial rupture the author advises rest with the tendon in a position of relaxation.

Tenosynovitis of the Long Head of the Biceps Brachii Muscle.—Tenosynovitis of the long head of the biceps muscle was found by Schrager [21] to be the most common cause of extra-articular pain in the shoulder joint in his cases. Trauma was the chief cause. Pain was definitely localized in the bicipital groove, and motion was limited much as in cases of bursitis. Schrager's treatment consists of heat and rest followed by diathermy and in cases of severe involvement by faradism. In some cases improvement is obtained by sudden traction on the arm while it is relaxed and abducted.

MISCELLANEOUS

Articular Osteochondroma.—Curnevali [22] studied microscopically osteochrondromatous nodules removed from the knees of patients. These nodules were in the final stage of a proliferating process. The cartilage had been preserved by osmotic nutrition, with resulting hyperplasia of the synovial membrane. This was followed by secondary metaplasia of the enlarged synovial villi into chondromatous nodules. Curnevali states that ossification progresses as long as the nodules have vascular connections.

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20. Waugh, R. L.: South. M. J. **31**:619, 1938.
21. Schrager, V. L.: Surg., Gynec. & Obst. **66**:785, 1938.
22. Curnevali, S. L.: Arch. di ortop. **53**:713, 1938.

Spontaneous Osseous Fissures.—Leriche and Jung [23] describe the case of a woman aged 38 who complained of dull pain in the region of both hips for three years. There was no history of trauma or illness. Roentgen examination revealed three cortical cracks, one in the inferior portion of the medial cortex of each femoral neck and one in the descending ramus of the pubis. There was slight periosteal reaction around each. The calcium content of both the serum and the urine was low, bordering on the values found in cases of tetany. Parathyroid extract, lime salts, vitamin D and ultraviolet irradiation were given. Eight weeks later the pains had greatly diminished. The values for calcium were approximately the same as when the patient was first seen. The authors mention 4 similar cases which they found reported in the literature. They offer no solution but feel that there is some underlying fault in the growth of the bones which produces this picture.

[ED. NOTE.—The condition in these cases is similar to the "pseudo-fracture" of the tibia recently reported but not as yet published by one of the editors.]

Spurs on the Os Calcis.—Steindler and Smith [24] contrasted two series of patients with painful spurs of the os calcis, one group being given conservative treatment with foot supports and the other being given operative treatment. There was very little to choose between the results in the two groups. Symptoms were controlled in 46.4 per cent of the patients conservatively treated. The percentage of successful operations was 59. The authors concluded that the symptoms of painful heel with spur of the os calcis may be controlled in about half the cases by conservative measures. When conservative treatment fails, operation is indicated. In the authors' cases, if simple excision of the spur was followed by recurrence a rotation osteotomy of the os calcis was performed.

Posterior Hernia of the Knee Joint.—Haggart [25] states that although a posterior hernia of the knee joint may simulate an internal derangement of the knee, the condition is correctly diagnosed when cystic swelling is found in the popliteal space, located usually in the midline and distal to the cutaneous flexion crease in this region. Clinically the symptoms vary from aching discomfort to severe, binding pain in the region of the knee, often associated with intermittent effusions into the knee joint and with moderate to marked disability. The hernial sac usually communicates with the joint by a pedicle 1 or 2 cm. in length, arising either above or below the oblique popliteal ligament. The hernial sac may occasionally dissect its way down the leg to the region of the

23. Leriche, R., and Jung, A.: Lyon chir. **35**:47, 1938.
24. Steindler, A., and Smith, A. R.: Surg., Gynec. & Obst. **66**:663, 1938.
25. Haggart, G. E.: J. Bone & Joint Surg. **20**:363, 1938.

midshaft and lie on top of the gastrocnemius muscle and beneath the deep fascia. Excellent drawings illustrating the anatomy of the region of the knee joint accompany Haggart's article. Microscopic examination reveals the lining of the hernial sac to be true mesothelium which cannot be distinguished from the synovial membrane of the knee joint. Signs of acute and chronic inflammation are present. Treatment is operative removal of the sac. An incision is made in the midline over the site of the swelling, the lower end of the incision being carried to the medial or the lateral side, depending upon the location of the sac. After division of the deep fascia, inspection reveals a fibroserous wall of the sac, which is freed by sharp dissection, beginning at the distal portion. It is necessary to divide some of the tendon and fibers of the gastrocnemius muscle. The popliteal nerves and vessels are displaced to the lateral side of the leg. When the sac is entirely free the pedicle is clamped, tied and cut. The stump is then inverted into the knee joint, and the foramen in the capsule is closed with heavy silk mattress sutures. A posterior plaster splint with the knee in full extension is applied for ten days. Exercises for "setting" the quadriceps muscle are given during this stage. Early weight bearing (with the patient on crutches) is encouraged.

ORTHOPEDIC OPERATIONS

Use of Os Purum in Bone Implantation.—Os purum, i. e., bone treated physicochemically, freed of connective tissue, fat and protein and then cleansed, was used by Orell [26] to promote bony healing in cases of tuberculosis of bones and joints. In both compact and spongy form the material was used to fill osseous defects left by surgical procedures and to fix (fuse) adjacent parts of the skeleton after resection of diseased tissue. By this method the author was successful in securing ankylosis of resected ankle joints in 6 of 8 cases. In 14 cases of arthrodesis of the knee the treatment was successful. Five shoulders were successfully fused. In addition some cases are reported in which tuberculous foci in the metacarpal or the metatarsal bones, the os calcis, the tibia, the femur and the pelvis were curetted and packed with os purum, with apparent healing. Most of the cases reported were followed for several years. The advantages of os purum are: (1) It may be stored for long periods; (2) there is no limit to the size and shape of the material used, and (3) an accessory operation to obtain fresh autoplastic bone is not necessary.

New Operative Treatment for Congenital Dislocation of the Hip.—Krinitzky [27] describes a new operation for congenital dislocation of the hip, to be used in "old" cases in which the dislocation cannot be reduced

26. Orell, S.: Surg., Gynec. & Obst. **66**:23, 1938.

27. Krinitzky, J. M.: Lyon chir. **35**:188, 1938.

bloodlessly. It consists in introducing a bone peg transversely through the subtrochanteric region of the femur until it enters the old acetabulum. The operation is done through a lateral incision over the upper femoral shaft, the direction and point of entry of the peg having been previously calculated by means of fluoroscopic examination. The desired objective is that the end of the peg shall lodge beneath the roof of the old acetabulum, so that when weight is borne on the leg the femur is prevented from riding up and rotation is limited. Six cases are reported, with follow-up during postoperative periods of six to twenty-two months. In all cases the limp was much lessened and stability was obtained. In 2 cases the bone peg increased in size.

Resection of the Elbow Joint.—Davidson and Horwitz [28] report 17 cases of resection of the elbow joint. In 2, resection was done for tuberculosis; in 13, for comminuted fractures or fracture-dislocations, and in 2, for old, irreducible dislocations of the elbow joint. Davidson and Horwitz used a longitudinal posterior incision, retracing the triceps tendon with a portion of the olecranon to expose the joint. About 1 inch (2.5 cm.) of the humerus and ½ to 1 inch (1.2 to 2.5 cm.) of the ulna and radius are resected. The results have been satisfactory for 9 adult patients but for only 2 children. Of the remaining children in the series (5), 2 showed fair results and 3 had ankylosis. One case is too recent for evaluation of the result. The authors concluded that the operation is satisfactory for adults and is at present the treatment of choice for tuberculous arthritis when conservative therapy has failed. It is contraindicated for children prior to the cessation of growth.

[ED. NOTE.—Fusion of the elbow joint in a useful position for function is the usually accepted therapy for tuberculosis when conservative treatment fails. For traumatic conditions with destruction of the elbow an arthroplasty with interposition of fascia seems to give a better and more stable joint.]

Major Amputations in the Aged.—Findley [29] reports 72 cases of major amputation of the lower extremity, in which 57 of the patients were treated at the New York City Hospital and at the Beekman Street Hospital, a private institution. Most of the patients in the first group were old and were surgically "poor risks," having arteriosclerotic or diabetic gangrene. The general mortality in this group was 54.4 per cent, while in the latter group the mortality was 46 per cent. Findley advises early operation and midthigh amputation. He uses the guillotine flap method without a tourniquet, with through and through sutures and drainage. Anesthesia induced with nitrogen monoxide and oxygen anesthesia is used. He advocates a speedy operation, that is, one per-

28. Davidson, A. J., and Horwitz, M. T.: Surgery **3**:226, 1938.
29. Findley, R. T.: Am. J. Surg. **39**:46, 1938.

formed within twenty minutes. In the first group, arteriosclerosis was the cause of disease in 32 per cent of the cases, diabetic gangrene in 32 per cent, thromboangiitis obliterans in 14 per cent and osteomyelitis in 9 per cent. In the second group, trauma alone was a factor in 47 per cent of the cases, embolism in 20 per cent, osteomyelitis in 13 per cent, diabetes in 7 per cent and diabetes with arteriosclerosis in 7 per cent. The average age in the second group was 43 and that in the first group 57 years.

Transplantation of the Brachioradialis Muscle for Weakness of the Triceps Muscle.—Ober and Barr [30] report a method of using the brachioradialis muscle for paralysis of the triceps muscle in cases of poliomyelitis. The brachioradialis muscle is exposed by an incision 4 inches (10 cm.) above the lateral epicondyle, extending downward on the posterolateral aspect of the humerus to 4 inches below the radial head on the lateral side of the forearm. The anterior margin of the brachioradialis muscle is defined, and its nerve and blood supply are found. The free anterior margin of the brachioradialis is rolled laterally and is sutured to the fascia and periosteum along the subcutaneous edge of the ulna, to the olecranon and to the triceps tendon. The arm is immobilized in full extension and supination. Exercises are started in ten days. Five patients have been operated on, and in all of them great improvement of function in extending the elbow has been noted.

Operation to Improve Function in Cases of Paralysis of the Quadriceps Muscle.—Yount [31] modifies his original operative technic [32] by a more radical dissection of the fascia lata in order to utilize effectively the muscular power available in the gluteus maximus muscle. Also, the biceps muscle is mobilized more freely in order to improve its direction of pull. By means of a long cutaneous incision the long head of the biceps muscle is separated from the short head. The fascia lata is stripped up to the insertion of the gluteus maximus muscle laterally, and the medial edge is freed up to the tensor fasciae femoris. A sheath is made of the remaining fascia lata to serve as a guide for the transplants. At the patella, insertion is made by two drill holes. Massage and muscular reeducation are begun the fifth week after operation. Braces are usually worn for six to eight weeks for walking. The operation is described in detail and illustrated with line drawings.

Opposition of the Thumb.—In an excellent and well illustrated article Bunnell [33] describes the "opposition" and goes into detail regarding the range of motion of the thumb. After naming the causes of

30. Ober, F. R., and Barr, J. S.: Surg., Gynec. & Obst. **67**:105, 1938.
31. Yount, C. C.: J. Bone & Joint Surg. **20**:314, 1938.
32. Yount, C. C.: J. Bone & Joint Surg. **8**:171, 1926.
33. Bunnell, S.: J. Bone & Joint Surg. **20**:269, 1938.

loss of opposition he describes methods of its restoration. He feels that there are two essential principles of tenoplasty. First, the tendon from its insertion in the thumb should be passed subcutaneously in the direction of the pisiform bone, so that it will pull the thumb in the correct direction, and second, the insertion of the tendon should be on the dorsoulnar aspect of the face of the proximal phalanx of the thumb, so as to restore the pronatory component. He also mentions briefly other methods of restoring opposition of the thumb, as described by other authors. The operative technic advocated adheres to the two essential principles mentioned. For motor power the flexor carpi ulnaris tendon, the palmaris longus tendon, the flexor digitorum sublimis tendon of the ring finger or any of the available long flexor muscle tendons may be used. The extensor carpi radialis brevis tendon or the palmaris longus tendon may be prolonged sufficiently by use of its prolongation, the palmar fascia, or any tendon desired can be pieced out by a free tendon graft either from the palmaris longus tendon or from any other tendon available. For the construction of a pulley at the pisiform bone, a free tendon graft from the palmaris longus or from any other available tendon can be looped around the short muscle and tendon attachment to the pisiform bone and sutured to itself, so that it forms a circle 2 cm. in diameter. The sutured junction is then slipped around until it is within the muscle. Instead of constructing a pulley one may pass the tendon used around the flexor carpi ulnaris tendon and on to its insertion in the phalanx of the thumb. For the sake of clarity, Bunnell's technic is shown in line drawings and photographs.

Treatment of Athetosis by Section of the Extrapyramidal Tract.—Putnam [34] reports 27 cases in which section of the extrapyramidal tracts in the spinal cord was done. Twenty-three of the patients were suffering from the "athetoid syndrome." Of these, 17 showed varying degrees of improvement. There were 3 postoperative deaths. In 4 of the 27 cases there was no improvement. On further analysis the patients in these cases were found to be of a different type from those with the "athetoid syndrome." The tremor was of a type of which paralysis agitans is the familiar example. In the series of 23 patients 12 were female and 11 male. The ages varied from 8 to 56. Thirteen had bilateral athetosis. Twelve had normal or superior mentality and 15 had a history of difficult delivery. The operation is carried out as high as possible, usually at the second cervical interspace. It consists of cutting the nonpyramidal motor pathways which lie in the anterior quadrant of the spinal cord, consisting of the vestibulospinal, reticulospinal and

34. Putnam, T. J.: Results of Treatment of Athetosis by Section of the Extrapyramidal Tracts in the Spinal Cord, Arch. Neurol. & Psychiat. **39**:258 (Feb.) 1938.

tectospinal pathways, with perhaps a few corticospinal fibers. If torticollis is present the operation is combined with section of the first three anterior roots. Putnam stresses the danger of operating on more than one side of the cord at one time.

Durham [35] found that marked internal rotation of the thigh in cases of cerebral spastic paralysis was not relieved by division of the adductor and flexor muscles and lengthening of the hamstrings but was relieved by division of those parts of the gluteus muscles which are attached anterior to the tip of the greater trochanter as well as by division of the tensor fasciae latae muscle. For this procedure a short diagonal cutaneous incision is made from behind immediately forward over the greater trochanter. Immobilization in plaster is used to maintain the thigh in abduction and full external rotation for six to eight weeks. Thirty-two operations of this nature have been performed on 20 patients in the past six years, with correction maintained in all cases.

Posterior Radicotomy for Spastic Paralysis.—Yovtchitch [36] speaks in defense of Foerster's operation, resection of the posterior nerve roots, in cases of severe spastic paralysis. He emphasizes the importance of muscular reeducation for all spastic patients. Tenotomy and the Stoffel operation should be utilized only for the milder forms of spasticity. The author expresses disagreement with those who feel that resection of the posterior nerve roots is too severe an operation for the spastic child to undergo. He has done 7 operations on 6 patients since 1925. Some of the operations have been cervical and some lumbar, and no untoward complications have followed any of them. It must be ascertained before operation that the child has sufficient intelligence to undertake postoperative muscular reeducation, and this sometimes requires a long period of observation. The author states that in every case the spasticity has subsided immediately after the operation, and in 1 case of athetosis the movement ceased. The results after several years of follow-up appear to be permanent. The author believes that no other procedure at present can equal the Foerster operation for severe spastic conditions.

[ED. NOTE.—This procedure has been given up almost entirely in America. It will be interesting to follow the author's opinion after he has had wider experience with this operation.]

FRACTURES

Fracture of the Atlas in Automobile Accidents.—Plaut [37] has added 6 cases of fracture of the atlas to the 93 recorded in the literature. The

35. Durham, H. A.: J. Bone & Joint Surg. **20**:339, 1938.

36. Yovtchitch, M.: Presse méd. **46**:689, 1938.

37. Plaut, H. F.: Fracture of the Atlas in Automobile Accidents: The Value of X-Ray Views for Its Diagnosis, J. A. M. A. **110**:1892 (June 4) 1938.

injury was due to force transmitted through the top of the skull (the patient's head hitting the top of the car) to the atlas with the head in an erect position. This force fell on the curved facets, breaking the ring of the atlas at the anterior or posterior arch. Roentgen technic and diagnosis are discussed. Injury to the spinal cord is rare, and treatment consists of immobilization for considerable time because of slow osseous repair.

Isolated Fractures of the Vertebral Arch.—Steiner [38] presents several cases of isolated fracture of the vertebral arch, particularly in the lumbar portion of the spine. Such fracture is observed in the articular processes, the interarticular portion or the pedicle. It may result from mild trauma and may explain some obscure forms of pains in the sacral region. Treatment is not described.

Valgus Position for Fractures of the Hip.—Cotton and Morrison [39] state that although it is well recognized that vastly better results are obtained in cases of intracapsular fracture of the neck of the femur if the displacement happens to be in the valgus position, it is only recently that they have learned how to produce this valgus position at will. Lateral roentgenograms of the hip have made it possible to determine the previously overlooked factor of forward rotation of the proximal end of the distal (neck) fragment. The procedure used by the authors is traction in the line of the femur, the hip and knee being moderately flexed; sharp adduction; crossing of the knee over the thigh of the sound side, and sharp inward rotation of the broken limb, followed by bringing down of the leg into slight abduction (about 20 degrees) without relaxation of the inward rotation. The results are then checked by anteroposterior and lateral roentgenograms. If they are not satisfactory the maneuver is repeated. If satisfactory position is attained the leg is abducted 20 or 30 degrees from the midline of the body, and a heavy wooden mallet is used to impact the fracture; a heavy layer of felt is placed over the greater trochanter, which is struck in line with the neck of the femur, the hammer being kept parallel with the table. This brings the femoral neck into an angle of from 105 to 110 degrees with the shaft. After reduction and impaction the fragments are nailed with Krupt nails, holes having been drilled under fluoroscopic control. The nails are then tapped home. The death of the femoral head, which occurs occasionally, is still a mystery and cannot be controlled by this method any better than by any of the others. However, the authors feel that should aseptic necrosis ensue, the valgus position is the posture in which the bone may best resist this misfortune. Excellent roentgenograms and line drawings are included in this article.

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38. Steiner, G.: Am. J. Roentgenol. **39**:43, 1938.

39. Cotton, F. J., and Morrison, G. M.: J. Bone & Joint Surg. **20**:46, 1938.

Central Fracture of the Neck of the Femur.—Campbell and his associates [40] have operated in 49 cases of complete central or intracapsular fracture of the neck of the femur, employing the three-flanged nail to secure internal fixation. Twenty-nine patients have been followed for over one year. Of these, 88 per cent are reported to show solid union. However, 9 per cent show degenerative changes indicative of devitalization of the femoral head, with an ultimate prognosis of poor function. Campbell states that internal fixation materially decreases the time in which union is secured, conserves the function of the hip and knee and decreases the mortality by reason of the less extensive means of immobilization and the shorter confinement to bed.

Fracture of the Neck of the Femur Treated by Oblique Osteotomy.—McMurray [41] reviews the method of Whitman and that of Smith-Petersen for the treatment of transcervical fracture. With Whitman's method union may be expected in 50 to 60 per cent of cases. With Smith-Petersen's method 70 to 80 per cent of patients obtain union, but of these about one fourth have aseptic necrosis of the femoral head within four or five years. Oblique osteotomy was first performed in 27 cases of nonunion of the neck of the femur and later was tried in 4 cases of recent fracture. In all these cases the result was satisfactory, the only deformity being a shortening of ½ to ¾ inch (1.2 to 1.9 cm.) and the only limitation being inability to adduct the leg across the middle line. The operation consists of osteotomy of the shaft of the femur just below and parallel to the lower border of the neck of the femur. The shaft is displaced inward, the cut surface of the shaft being brought close beneath the line of fracture through the neck and beneath the lower border of the acetabulum. The limb is enclosed in a plaster spica in the neutral position. Callus formation extends from the shaft into the cervical fracture line, fusing all three fragments and giving a stable, painless hip with good range of motion, limitation being present only in adduction.

Ambulatory Method of Treating Fracture of the Femoral Shaft.—Anderson [42] describes a further elaboration of his apparatus [43] for fixation of fracture of the femoral shaft. The half pins are placed through the femoral shaft at an angle, and their protruding ends are connected by a bar. Two pins, also at an angle, are drilled through the femoral condyles from the inner side. After the fracture has been reduced, the thigh, with the upper and the lower pin, is incorporated in plaster. The entire procedure is usually carried out on a fracture

40. Campbell, W. C.: Minnesota Med. **21**:260, 1938.
41. McMurray, T. P.: Brit. M. J. **1**:330, 1938.
42. Anderson, R.: Am. J. Surg. **39**:538, 1938.
43. Anderson, R.: J. Bone & Joint Surg. **16**:379, 1934.

table. Roentgenograms are taken to secure fixation in proper position. The plaster is trimmed at the groin and at the knee to permit motion at the knee and hip joints. Walking is permitted as soon as the plaster is dry and the general condition of the patient permits. There is usually no pain. The apparatus is removed as a rule in eight to twelve weeks.

Fractures of the Elbow in Children.—Robertson [44] reviews the general principles governing the treatment of fractures of the elbow. He advises immediate reduction to prevent unnecessary pain and to improve circulation. No sedative should be given without certainty that normal circulation is present in the fingers. For fracture involving the articular surface, a perfect reduction, by open operation if necessary, is essential.

Fractures of the Forearm.—Kotrnetz [45] lists the results of treatment for fracture of the forearm in the Second Surgical University Clinic in Vienna, Austria, considering the material in two divisions, fractures in children and fractures in adults. The methods of Boehler were regularly employed. The data for the first group are as follows: One hundred and eight fractures in the distal third of the radius were treated. Only those with more than 15 per cent of angulation were subjected to reposition. An average of twenty-seven days in a short arm plaster cast was employed. In 3 cases there was refracture after removal of the plaster in three weeks. There were 24 cases of fracture of the middle and the proximal third of the radius; in 21 reduction was done; forty-three days was the average period of immobilization, which was obtained principally by plaster casts including the elbow. In 1 case there were circulatory difficulties despite early splitting of the plaster, and in 2 cases refracture occurred in spite of long fixation. Eleven isolated fractures of the ulna were treated by immobilization in a long arm plaster cast for an average of thirty-one days. In 2 cases refracture occurred after four weeks of immobilization. One case, in which healing had occurred with considerable lateral displacement of one fragment, was reviewed five years after the original fracture. No sign of the displacement or the site of fracture was demonstrable. Greenstick fracture of both bones in the distal third was treated with both short and long arm plaster casts in 68 cases. An average of twenty-four days' immobilization was employed. In 57 cases reduction was required. In 4 of these a second reduction was necessary after ten to fourteen days, and in 1 there was refracture four weeks later because of malposition. Results were uniformly good except in 1 case in which there was loss of 20 per cent of supination and slight (less than 15 per cent) axial deformity; in 2 cases refracture occurred after removal of the plaster. Subperiosteal or greenstick fracture in the middle and the

44. Robertson, D. E.: Am. J. Surg. **39**:327, 1938.

45. Kotrnetz, H.: Arch. f. orthop. u. Unfall-Chir. **38**:673, 1938.

proximal third of both bones was treated in 111 cases, the average period of immobilization (in a long arm plaster cast) being forty-eight days. Three patients were left with mild angulation and lost 30 per cent of supination. Otherwise the end results were excellent. A striking feature was the fact that there were 14 cases of circulatory disturbance requiring splitting of the plaster and 4 cases in which refracture occurred. Two fractures with punctures of the skin healed without complication. In 36 cases of fracture of the distal third of both bones with lateral displacement the average period of immobilization in plaster was forty-six days. Eight temporary circulatory disturbances were noted; 4 resulted in slight radial angulation of 1 in a loss of 20 degrees of supination. Of 40 fractures of both bones in the middle and the proximal third of the forearm with lateral displacement, 37 were reduced by the close method and 3 required the use of operative methods (2 being treated by double wire traction and 1 by plating with the Lane plate). Thirteen fractures were reduced under the fluoroscope. The average period of immobilization was fifty-seven days. The end results were good. In 5 cases there was slight dorsal angulation and in 3 a 20 per cent loss in supination. In summary, of these 398 fractures in children treated by unpadded plaster, it may be said that the results are excellent. The author explains the occurrence of circulatory disturbance in 32 cases as caused by the development of a secondary, operatively produced hematoma during the manually produced fracture of the remaining cortex in correction of greenstick deformities. He believes delaying reduction for twenty-four hours will help for greenstick lesions but that early reduction will help most for lesions with lateral displacement. He notes the frequency of refracture in children and advises continued guarding even after roentgenographic union has occurred.

The data in the second group are as follows: Of 34 fractures of the radius in the middle and the proximal third, 26 required reduction; 1 required open reduction. There were 6 circulatory disturbances; 1 untreated for four days, ended disastrously. In the study of end results, 4 presented limitation of pronation and supination. All were treated simply by fixation in plaster (long arm cast) even if the distal ulnar-radial ligaments were torn. The hand was fixed in supination for fractures of the proximal third and in midposition for fractures of the distal third. Of 24 fractures of the ulnar shaft union was obtained after an average of fifty-eight days' fixation in plaster (long arm cast). Only 5 had showed any displacement. Of 30 fractures of the shafts of both bones, 17 were treated by fixation, 8 by double wire fixation and 5 by open operation. Aside from the cosmetic inferiority of the results in cases in which casts were used, the results statistically seem as good as in those in which wire extension was used.

[ED. NOTE.—This large series of fractures of the forearm treated for the most part by simple means suggests that careful supervision through the entire period of healing is the best guarantee of a satisfactory result.]

Fracture Disabilities of the Forearm.—Steindler [46] reviews the disabilities following fracture of the forearm. He lists these under (1) malalinement of Colles' fracture, (2) nonunion of fracture, (3) arthritis of the wrist joint and (4) soft tissue contractures. These common disabilities can be largely prevented by more perfect reduction of the fracture. Disturbances of the nerves and circulation are not always preventable. Early repair of neural lesions, judicious physical therapy, adequate splinting, elevation of the forearm, freedom of the fingers, passive motion and subsequent exercises are of greatest importance.

Injuries to the Triangular Ligament of the Wrist.—Guillermo [47] stresses the fact that injuries to the triangular ligament of the wrist often are unrecognized and may lead to persistent disability. The ligament is biconcave and acts as an elastic cradle for the head of the ulna. It originates from two roots, one from the inferior surface of the radius and the other from the small sigmoid cavity of the radius, and extends horizontally beneath the head of the ulna to terminate in two roots, one on the external aspect of the ulnar styloid process and the other between the styloid process and the head of the ulna. During supination and pronation the radius rotates around the axis, passing through the head of the ulna. During these movements the triangular ligament acts as a shock absorber and takes the pressure of the hand from the ulnar head. During a fall on the hand with the wrist in pronation the ligament is put on the stretch and prevents separation of the radius and the ulna. An osseous injury to the lower part of the radius or the ulna may involve the triangular ligament, but injury to the ligament may also occur in the absence of osseous injury. Hence, roentgenographic integrity of the bones does not necessarily mean that the ligament has not been damaged. Clinical signs of injury to the ligament may be present. With rupture of the ligament there may be dorsal displacement of the ulna, and if this has occurred the head of the ulna may be moved up and down by pressure with the thumb. This sign has no significance in children because of the flexibility of the ligament. In the presence of an old lesion there may be crepitus in the wrist on motion, or a definite click may be felt as the head of the ulna is pushed into place. Pain and limitation of supination and pronation may result from separation of the radius and the ulna. In case of persistent disability the author advises removal of the triangular ligament.

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46. Steindler, A.: J. Connecticut M. Soc. **2**:163, 1938.
47. Guillermo, J.: Rev. d'orthop. **25**:125, 1938.

Fractures of the Scapula and Ribs.—Findlay [48] reviews 37 cases of fracture of the scapula and 163 cases of fracture of the ribs. In 25 of the scapular fractures there were associated bony injuries in other parts of the body. Associated fractures of the ribs were most common. The body of the scapula was the most commonly fractured, this being the site of fracture in 29 cases. Other fractures were distributed as follows: glenoid fossa, 7; acromion, 4; spine, 2; neck, 2; coracoid process, 2. The treatment is rest in bed and support, usually followed by heat, massage and exercise of the shoulder after the first week. Open reduction was attempted in 1 case but was unsuccessful. Incomplete fractures were treated with a sling, and the patients were allowed to walk. Four of these patients died in the hospital from multiple injuries. Of 12 that could be traced, 8 showed good results, 3 fair results and 1 a poor result. Most of these fractures occurred in middle-aged laborers. The ribs most frequently fractured were the fifth, sixth and seventh. The first and the twelfth were least often broken. Forty of the patients died in the hospital from associated injuries. Among these there were 5 with laceration of the lung, 6 with hemothorax and 6 with hemopneumothorax. The common form of treatment was strapping with adhesive plaster. The end results in 25 of 32 cases were good; 7 patients had persistent pain. When there is severe respiratory embarassment with fracture of the ribs, unrelieved by strapping, the administration of oxygen is advocated. For hemothorax the author suggests, but has not tried, aspiration and replacement of the fluid with sterile air. An increase in temperature to 104 or 105 F. after a slight, constant fever in the presence of pleural effusion or hemothorax suggests the probable presence of empyema.

Treatment of Slipping of the Upper Femoral Epiphysis.—Wilson [49] discusses two points: (1) the treatment of early stages of slipping of the upper femoral epiphysis, and (2) the effect of operative fusion of the upper femoral epiphysis on growth of the lower extremity. Early treatment requires alertness on the part of the physician to make a correct diagnosis. In this case of a patient between the ages of 10 and 16 years, complaining of intermittent pain and stiffness in the knee or thigh, with at times a noticeable limp, one should consider slipping of the epiphysis as one of the first possibilities. In approximately 70 per cent of cases the patient is overweight. Roentgen examination reveals irregular rarefaction of the metaphysial zone of the neck in immediate contact with the epiphysial cartilage, giving a characteristic appearance of widening of the epiphysial line. This is always evident, especially on comparison with the normal hip. The author believes that

48. Findlay, R. T.: Am. J. Surg. **38**:489, 1937.

49. Wilson, P. D.: J. Bone & Joint Surg. **20**:379, 1938.

real slipping occurs as soon as the epiphysis is loosened. Without slipping it is doubtful if there would be any symptoms. A lateral roentgenogram usually gives more information than an anteroposterior one. Treatment consists of fixation as soon as a diagnosis is made. With the patient under general anesthesia an incision is made over the lateral aspect of the trochanter, and the Smith-Petersen nail is started at a point about 1 inch (2.5 cm.) below the ridge for the insertion of the vastus lateralis muscle. The leg is held by an assistant with the hip internally rotated as much as possible, and the nail is driven home at the angle and to the depth previously determined from measurements of the roentgenogram of the hip. Arthrotomy of the hip joint is not necessary, and replacement of the slightly displaced head is not necessary unless the head has slipped off more than one third of the diameter of the neck of the femur. Fusion of the upper femoral epiphysis has shown that serious shortening of one extremity does not result. Certainly growth from the epiphysis has been known to stop when nailing or drilling through this region is done, but follow-up studies in 9 cases revealed no increase in the amount of shortening after the operation. Closure of the unaffected epiphysis usually takes place within two years after the occurrence of slipping, which is frequently considerably in advance of the normal time. The author gives complete histories of the 9 cases reported, showing roentgenograms, pictures and photographs of the patients.

After-Care of Fracture.—In the after-care of fracture, Hoke and his associates [50] advise roentgen examination of reduced fractures once a week until there is sufficient union to prevent slipping. In the healing of fractures there should be no pain. Pain is usually the result of undue pressure on the body from the retaining apparatus. All apparatus should be so arranged by skeletal plaster fixation or skeletal plaster traction that the patient can be moved from his bed to a wheel chair daily. Compound fractures, after cleaning and reduction, are packed with petrolatum gauze to permit drainage and healing of the wound. Motion in the joints adjacent to a fracture should be begun when there is sufficient callus to prevent displacement of the fragments. Firm union of the fractured bone, however, is more important than articular motion. For recovering motion in a joint, heat, massage and the galvanic current are of value. The authors describe simple splints to protect the site of fracture when use is first resumed.

Functional Disabilities After Simple Fracture.—Gurd [51] discussed disabilities arising from simple fracture and not due to easily recognized causes, such as shortening, angulation or nonunion. He suggests that

50. Hoke, M.; Thornton, L., and Sandison, C.: J. M. A. Georgia **27**:10, 1938.
51. Gurd, F. C.: Surg., Gynec. & Obst. **66**:489, 1938.

disability following apparently uncomplicated fractures is often due to osseous atrophy and associated changes in tendons and ligaments. The chief cause for such atrophy, he concludes, is hyperemia. This hyperemia persists because of irritation at or about the site of fracture. The main causes of such irritation are: (1) inadequate fixation, and (2) short period of absolute fixation to prevent atrophy. Adequate fixation of sufficient duration should be employed, and at the same time function should be established as completely and easily as possible; i. e., with fracture of the lower extremity protected weight bearing should be begun, and in the upper extremity there should be absolute fixation of the area of fracture with as great freedom as possible for the hand and fingers.

Functional Disabilities after Simple Fracture.—Every fracture should be regarded as a potential source of permanent disability, according to Henderson.[52] He mentions the posterior deformity of the wrist caused by Colles' fracture, the posterior displacement caused by supracondylar fracture of the humerus and the sometimes associated Volkman's contracture. At the ankle joint the common deformities are nonunion of the internal malleolus, valgus deformity and valgus deformity with posterior displacement. At the hip joint, nonunion of fracture of the femoral neck is the most common. Physical therapy and methods of correcting these deformities are discussed.

RESEARCH

Influence of the Sympathetic Nervous System on Healing of Fractures.—Lexer [53] first reviews the literature on sympathectomy. He then recounts the findings of Wassiljeff and Scholondz,[54] who noted marked differences in homoplastic graft healing in sympathectomized dogs. Using rabbits, Lexer repeated the experiments. He found that while the leg operated on was apparently stimulated to repair the defect faster than it was repaired on the normal side, no true healing of the transplant to its base took place. In 34 sympathectomized animals and 21 controls the author studied callus formation after manually fracturing the femur. At various stages of healing the animals were killed, and the vascular network of the callus was visualized roentgenographically by injection of opaque mediums. Histologic sections were also prepared. It appeared that although the callus was larger in the sympathectomized animals, union of the fracture was always slower. While sympathectomy may speed up callus formation in cases of delayed union, it is clinically uncertain and dangerous. In the presence of true pseudarthrosis sympathetic division is completely without value.

52. Henderson, M. S.: Arch. Phys. Therapy **19**:7, 1938.
53. Lexer, E. W.: Deutsche Ztschr. f. Chir. **249**:337, 1937.
54. Wassiljeff, A. A., and Scholondz, A. M.: Arch. f. klin. Chir. **178**:148, 1933.

Diffraction Studies on Human Bone.—Reynolds, Hayden and Corrigan [55] present an interesting preliminary report on roentgen ray diffraction patterns of bone and quantitative chemical analyses. They have found that diffraction patterns of bone from patients with Paget's disease and normal bone show an apatite (calcium phosphate fluoride or calcium phosphate chloride) structure. Diffraction patterns of bone from a patient with parathyroidism show a structure different from apatite.

Pathogenesis of Perthes' Disease.—Nagura and Kosuge [56] ingeniously reproduced experimentally the early changes of Legg-Perthes disease in rabbits. Using rabbits 4 weeks old, the authors exposed the hip and with a sharp knife produced a "traumatic injury" to the epiphysial plate. The animals were allowed to walk around normally and were killed in three to thirty-six days after operation. The changes were studied grossly and microscopically. The immediate picture showed only separation where the knife had entered. Later there was regeneration, consisting of chondrogenesis and spongiogenesis. Secondary clefts arose in the epiphysial plate and articular cartilage. There was deformity, usually flattening of the femoral head. The lesions were progressive, and the authors believed that complete healing did not occur while the animal walked around. The authors concluded, after discussing the various theories of the causation of Legg-Perthes disease (infection, infectious osteochondritis, bony necrosis and mycotic emboli), that the condition is due to minor injuries to the head of the femur. Weight bearing as long as the injury is not healed causes irregular growth. The fact that a history of injury is only rarely obtained indicates that the patients do not remember incidents of slight trauma.

Round Ligament and Vascularization of the Femoral Head.—This study was undertaken by Nordenson [57] to determine the presence and caliber of arteries in the ligamentum teres in patients of different age groups. The material comprised 129 normal hips, the ages of the patients ranging from infancy to 90 years, with a good distribution in the various decades. Twenty patients with intracapsular fractures of the femoral neck also were examined. The method of study consisted of excision of the entire ligamentum teres, including a portion of the adjacent head of the femur. The specimens were then fixed and cut into serial sections for histologic study. The arteries were not injected, the author concluding that this procedure is apt to lead to false results. In 91 of the 129 normal ligaments, vessels of fair size were

55. Reynolds, L.; Hayden, H. S., and Corrigan, K. E.: Am. J. Roentgenol. **39**:286, 1938.

56. Nagura, S., and Kosuge, S.: Arch. f. klin. Chir. **191**:347, 1938.

57. Nordenson, N. G.: Lyon chir. **35**:178, 1938.

easily traced into the femoral head. In 14 cases no vessel or only very feeble vessels were found. In 24 cases there were vessels in the proximal part of the ligament, which, however, soon broke up into small branches and were difficult or impossible to trace into the head. In 15 cases vessels had been obliterated by arteriosclerosis. Arteries in the ligament were observed in specimens from all age groups, but in those from the higher age groups vessels were more frequently lacking or small or had been obliterated by arteriosclerosis. The blood supply, when present, was never by a single artery but always by several small arteries. Vessels were demonstrated in each of the 20 cases in which intracapsular fracture had occurred. It is interesting to note that in nearly all of these the vessel was of larger caliber than those found in the normal hip, indicating an ability of the arteries to adapt themselves to the increased demand for blood in the femoral head.

Anatomy of the Sternoclavicular Joint.—Remarking on the paucity of reports on the sternoclavicular joint, Rathcke,[58] after reviewing the standard anatomic descriptions describes his findings in various specimens classified according to age. He observes that more often than not the two joint compartments formed by the intra-articular disk communicate at one point. The fibers of the disk in youth have a regular pattern, and blood vessels are visible only peripherally. With advancing age the pattern becomes less clear. The disk is fragmented in places and becomes stained a yellowish color (this is similar to Schmorl's observations on the intervertebral disks). No synovial lining was found. The occurrence of effusion in the joint, therefore, is questioned by Rathcke. With advancing age, just as the disk undergoes attritional changes similar to those seen in the meniscuses, the component joint surfaces of the clavicle and the sternum lose gradually their hyaline cartilage.

58. Rathcke, L. D.: Ztschr. f. Chir. **249**:162, 1938

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